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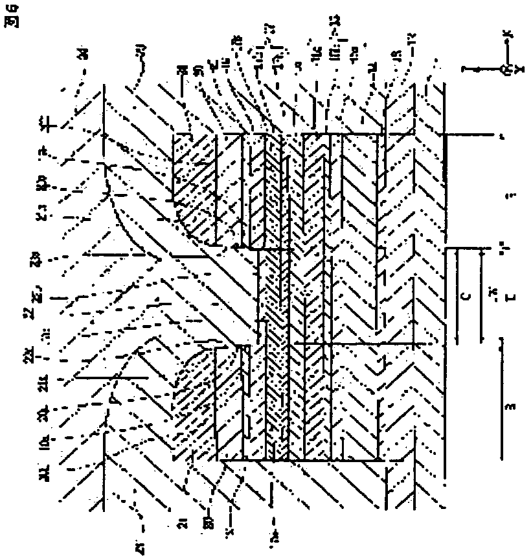
(54) METHOD FOR MANUFACTURING MAGNETIC DETECTING ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To solve the problem that it is difficult to form a magnetic detecting element capable of surely applying a longitudinal bias to a free magnetic layer in a method for manufacturing an exchange bias type magnetic detecting element, in which a ferromagnetic layer for applying the longitudinal bias to both side end faces of the free magnetic layer of faces to be cut by milling is connected.
SOLUTION: The method for manufacturing the magnetic detecting element comprises the steps of laminating a ferromagnetic layer 19 and a second antiferromagnetic layer 20 on the nonmagnetic layer 18 formed in a predetermined thickness, then digging out the layer 20 to form a recess 22, and thereby forming the magnetic detecting element in which the free magnetic layer 17 can be surely formed in a single domain in the track width direction.



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CLAIMS

[Claim(s)]
[Claim 1] (a) the process which forms the multilayers which have the 1st antiferromagnetism layer, a fixed magnetic layer, a non-magnetic material layer, a free magnetic layer, and a non-magnetic layer on a substrate, and (b) -- said multilayers in the field of the 1st heat treatment temperature and the 1st magnitude The process which anneals among the 1st magnetic field and fixes the magnetization direction of said fixed magnetic layer in the predetermined direction, (c) The process which forms a ferromagnetic layer and the 2nd antiferromagnetism layer on said multilayers, (d) The process in which a side face penetrates said 2nd antiferromagnetism layer and said ferromagnetic layer, and a base forms the crevice located in said non-magnetic layer, (e) when said 2nd antiferromagnetism layer anneals the multilayers by which the laminating was carried out among the 2nd magnetic field in the field of the 2nd heat treatment temperature and the 2nd magnitude The manufacture approach of the magnetic sensing element characterized by having the process which fixes the magnetization direction of said free magnetic layer in the magnetization direction of said fixed magnetic layer, and the crossing direction.
[Claim 2] instead of [of the process of the above (d)] -- (f) -- the manufacture approach of a magnetic sensing element according to claim 1 of having the process at which a base forms in said 2nd antiferromagnetism layer the crevice located in said 2nd antiferromagnetism layer.
[Claim 3] The manufacture approach of the magnetic sensing element according to claim 2 which makes more greatly than 0A thickness of the field of said 2nd antiferromagnetism layer located in the lower part of the base of said crevice 50A or less in the process of the above (f).
[Claim 4] The manufacture approach of a magnetic sensing element according to claim 1 of having the process in which the (g) side face penetrates said 2nd antiferromagnetism layer, and a base forms the crevice located in said ferromagnetic layer instead of the process of the above (d).
[Claim 5] The manufacture approach of a magnetic sensing element according to claim 1 to 4 of having the process which opens spacing crosswise [truck] and carries out the laminating of the electrode layer of a pair on said 2nd antiferromagnetism layer.
[Claim 6] The manufacture approach of a magnetic sensing element according to claim 5 that a distance-across-vee dimension forms a crevice equal to the width of recording track by deleting the part across which opened spacing crosswise [truck], and carried out the laminating of the electrode layer of a pair, and the electrode layer of said pair of said 2nd antiferromagnetism layer faced on said 2nd antiferromagnetism film in the process of the above (d), (f), or (g).
[Claim 7] The manufacture approach of the magnetic sensing element according to claim 5 which forms a crevice by deleting the part across which opened spacing of the truck cross direction, and carried out the laminating of the 1st resist layer of a pair, and said 1st resist layer of said 2nd antiferromagnetism layer faced on said 2nd antiferromagnetism layer in the process of the above (d), (f), or (g).
[Claim 8] The process which is the inside of the (h) aforementioned crevice, and on said 2nd antiferromagnetism layer, and forms the 2nd resist layer on the outskirts of opening of said crevice after forming said crevice in the process of the above (d), (f), or (g) and removing said 1st resist layer, (i) The manufacture approach of a magnetic sensing element according to claim 7 of having the process which forms an electrode layer to the field which is not covered with said resist layer on said 2nd antiferromagnetism layer, and the process which removes the resist layer of the (j) above 2nd.
[Claim 9] After forming said crevice in the process of the above (d), (f), or (g) and removing said 1st resist layer (k) The process at which the width method of the truck cross direction at the bottom forms the 2nd resist layer smaller than the distance-across-vee dimension of said 1st resist layer on the base of said crevice, (l) The manufacture approach of a magnetic sensing element according to claim 7 of having the process which applies on said 2nd antiferromagnetism layer from the inside of said crevice, and forms an electrode layer, and the process which removes the resist layer of the (m) above 2nd.
[Claim 10] The process which has the process which forms a lower electrode layer and forms an insulating layer

instead of the process of the above (d), (f), or (g) on the (n) substrate before the aforementioned (a) process at the antiferromagnetism layer top of the (o) above 2nd, (p) The process which forms a crevice on said insulating layer by deleting the part which carries out the laminating of the resist which prepared the hole in the center section of the truck cross direction, and is exposed to said hole of said insulating layer and said 2nd antiferromagnetism layer, (q) The manufacture approach of a magnetic sensing element according to claim 1 to 4 of having the process which forms in the base of said crevice the up electrode layer which flows electrically.
[Claim 11] between the aforementioned (p) process and the aforementioned (q) processes -- (r) -- the process which applies on said insulating layer from said crevice, and forms other insulating layers, and (s) -- the laminating was carried out on the base of said crevice -- said -- others -- the manufacture approach of a magnetic sensing element according to claim 10 of having the process which removes an insulating layer.
[Claim 12] The aforementioned (n) process and the process which forms the lobe projected in said direction of multilayers in the center of the truck cross direction of the (t) aforementioned lower electrode layer between the aforementioned (a) processes, (u) The manufacture approach of the magnetic sensing element according to claim 10 or 11 which forms said multilayers so that it may have the process which prepares an insulating layer in the both-sides section of the truck cross direction of said lobe of said lower electrode layer and the top face of said lobe may touch the inferior surface of tongue of said multilayers in the aforementioned (a) process.
[Claim 13] The manufacture approach of the magnetic sensing element according to claim 12 which makes the top face of said lobe, and the top face of said insulating layer prepared on the both-sides edge of said lower electrode layer the same flat surface in the aforementioned (u) process.
[Claim 14] The manufacture approach of the magnetic sensing element according to claim 10 to 13 which forms said lower electrode layer and/or said up electrode layer with a magnetic material.
[Claim 15] The manufacture approach of the magnetic sensing element according to claim 10 to 14 which forms said up electrode layer as that to which the laminating of the base of said crevice, the layer formed with the nonmagnetic conductivity ingredient which flows electrically, and the layer formed with a magnetic material was carried out.
[Claim 16] The manufacture approach of the magnetic sensing element according to claim 10 to 15 which forms said non-magnetic material layer with a nonmagnetic electrical conducting material.
[Claim 17] The manufacture approach of the magnetic sensing element according to claim 10 to 15 which forms said non-magnetic material layer by the insulating material.
[Claim 18] The manufacture approach of a magnetic sensing element according to claim 1 to 17 of setting the 2nd heat treatment temperature as temperature lower than the blocking temperature of the 1st antiferromagnetism layer in the process of the above (e).
[Claim 19] The manufacture approach of the magnetic sensing element according to claim 1 to 18 which makes magnitude of the 2nd field smaller than the exchange anisotropy field of the 1st antiferromagnetism layer in the process of the above (e).
[Claim 20] The manufacture approach of the magnetic sensing element according to claim 1 to 19 which forms said non-magnetic layer with a conductive ingredient in the process of the above (a).
[Claim 21] The manufacture approach of the magnetic sensing element according to claim 20 which forms said non-magnetic layer with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os in the process of the above (a).
[Claim 22] The manufacture approach of the magnetic sensing element according to claim 21 which forms said non-magnetic layer so that it may consist of Ru and thickness may be set to 0.8-1.1nm.
[Claim 23] The manufacture approach of the magnetic sensing element according to claim 1 to 21 which forms the conductive ingredient layer which specific resistance becomes from a conductive ingredient lower than said non-magnetic layer between said non-magnetic layers and said free magnetic layers in the process of the above (a).
[Claim 24] The manufacture approach of the magnetic sensing element according to claim 23 which forms said non-magnetic layer so that it may consist of Ru and thickness may be set to 0.4-1.1nm.
[Claim 25] The manufacture approach of the magnetic sensing element according to claim 23 or 24 which forms said conductive ingredient layer so that it may consist of Cu and thickness may be set to 0.3-0.5nm.
[Claim 26] The manufacture approach of the magnetic sensing element according to claim 1 to 25 formed by carrying out the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs said fixed magnetic layer through a nonmagnetic interlayer in the process of the above (a).
[Claim 27] The manufacture approach of the magnetic sensing element according to claim 1 to 26 formed by carrying out the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs said free magnetic layer through a nonmagnetic interlayer in the process of the above (a).
[Claim 28] The manufacture approach of the magnetic sensing element according to claim 26 or 27 which forms

said nonmagnetic interlayer with one sort or two sorts or more of alloys among Ru, Rh, Ir, Os, Cr, Re, and Cu.
[Claim 29] The manufacture approach of the magnetic sensing element according to claim 1 to 28 which forms at least one side using the magnetic material which has the following presentations among said ferromagnetic layers and said free magnetic layers. It is the magnetic material whose remaining presentation ratios an empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and are Co(es).
[Claim 30] The manufacture approach of the magnetic sensing element according to claim 1 to 28 which forms the interlayer who consists of a CoFe alloy or Co between said non-magnetic material layers and said free magnetic layers.
[Claim 31] The manufacture approach of the magnetic sensing element according to claim 30 which forms at least one side using the magnetic material which has the following presentations among said ferromagnetic layers and said free magnetic layers. It is the magnetic material whose remaining presentation ratios an empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 15 atom % above 7 atom %, the presentation ratio of nickel is below 15 atom % above pentatomic %, and are Co(es).
[Claim 32] The manufacture approach of the magnetic sensing element according to claim 29 or 31 which forms both said ferromagnetic layers and said free magnetic layers using said CoFeNi.
[Claim 33] The manufacture approach of the magnetic sensing element according to claim 1 to 32 which forms said 1st antiferromagnetism layer and said 2nd antiferromagnetism layer using the antiferromagnetism ingredient of the same presentation.
[Claim 34] Said 1st antiferromagnetism layer and/or said 2nd antiferromagnetism layer A PtMn alloy, Or it is a X-Mn (however, X is one-sort [any] or two sorts or more of elements of Pd, Ir, Rh, Ru, Os, nickel, and Fe) alloy, or is Pt-Mn-X' (however, X'). The manufacture approach of the magnetic sensing element according to claim 1 to 33 formed with the alloy which are any one sort or two sorts or more of elements of Pd, Ir, Rh, Ru, Au, Ag, Os, Cr, nickel, Ar, Ne, Xe, and Kr.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the magnetic sensing element which can mainly start the manufacture approach of the magnetic sensing element used for a magnetometric sensor, a hard disk, etc., especially can raise field ability to detect.
[0002]
[Description of the Prior Art] Drawing 38 is the sectional view which looked at the structure of the magnetic sensing element formed by the conventional manufacture approach from the opposed face with a record medium.
[0003] The magnetic sensing element shown in drawing 38 is called the spin bulb mold MAG sensing element which is one sort using giant magneto-resistance of a GMR (giant magnetoresistive) component, and detects the record field from record media, such as a hard disk.
[0004] The multilayers 8 by which this spin bulb mold MAG sensing element was constituted from the bottom by a substrate 1, the substrate layer 2, the 1st antiferromagnetism layer 3, the fixed magnetic layer (pin (Pinned) magnetic layer) 4, the non-magnetic material layer 5, the free magnetic layer (Free) 6, and the protective layer 7, It consists of the 2nd antiferromagnetism layers 10 and 10 and the electrode layers L and L of a pair which were formed the ferromagnetic layers 9 and 9 of the pair formed in the both-sides section of these multilayers 8, and on these ferromagnetic layers 9 and 9.
[0005] Generally Cr film is used for the 1st antiferromagnetism layer 3 and the 2nd antiferromagnetism layers 10 and 10 in Ta and the electrode layers L and L by the nickel-Fe (nickel-iron) alloy film and the non-magnetic material layer 5 at Cu (copper) film, the substrate layer 2, and a protective layer 7 at the Pt-Mn (iron-manganese) alloy film, the fixed magnetic layer 4, the free magnetic layer 6, and the ferromagnetic layers 9 and 9.
[0006] Magnetization of the fixed magnetic layer 4 is single-domain-ized by the exchange anisotropy field with the 1st antiferromagnetism layer 3 in the direction (the direction of a leakage field from a record medium; the height direction) of Y.
[0007] Moreover, the ferromagnetic layers 9 and 9 are single-domain-ized in the direction of X by the exchange anisotropy field with the 2nd antiferromagnetism layers 10 and 10. The ferromagnetic layers 9 and 9 and the free magnetic layer 6 have touched in Joints J and J, and he is trying to become the continuous ferromagnetism object. Thus, the free magnetic layer 6 is single-domain-ized in the direction of X by the so-called exchange bias method. By the exchange bias method, there is an advantage that the anti-field which surface magnetic charge does not generate in the both-sides end face (joints J and J) of the free magnetic layer 6, but is generated in the free magnetic layer 6 can be made small.
[0008] In a magnetic sensing element, a detection current (sense current) is given to the free magnetic layer 6, the non-magnetic material layer 5, and the fixed magnetic layer 4 from the electrode layers L and L through the 2nd antiferromagnetism layers 10 and 10 and the ferromagnetic layers 9 and 9. The transit direction of record media, such as a hard disk, is a Z direction, and if the leak field from a record medium is given in the direction of Y, magnetization of the free magnetic layer 6 will change from X towards the direction of Y. Electric resistance changes by the relation between fluctuation of the direction of magnetization within this free magnetic layer 6, and the fixed magnetization direction of the fixed magnetic layer 4 (this is called magneto-resistive effect), and the leak field from a record medium is detected by the electrical-potential-difference change based on this electric resistance value change.
[0009]
[Problem(s) to be Solved by the Invention] When manufacturing the magnetic sensing element of drawing 38 , after forming each of the substrate layer 2, the 1st antiferromagnetism layer 3, the fixed magnetic layer 4, the non-magnetic material layer 5, the free magnetic layer 6, and a protective layer 7 as uniform film on a substrate 1, it deletes except the part used as the multilayers 8 of drawing 38 by ion milling. Then, the ferromagnetic layers 9 and 9 are formed so that the side faces 8a and 8a of multilayers 8 may be touched directly, and the 2nd

antiferromagnetism layers 10 and 10 and the electrode layers L and L are further formed on the ferromagnetic layer 9 and 9.

[0010] That is, in the magnetic sensing element of drawing 38 , the side faces 8a and 8a of multilayers 8 are the interfaces deleted by milling. Even if it formed the ferromagnetic layers 9 and 9 to the interface deleted by such milling so that it might touch directly, it was difficult to use the ferromagnetic layers 9 and 9 and the free magnetic layer 6 as the ferromagnetism object which continued in Joints J and J, and it difficult to change the free magnetic layer 6 into the single domain-ized condition stabilized in the direction of X.

[0011] Moreover, since the joints J and J of the ferromagnetic layers 9 and 9 and the free magnetic layer 6 were on side-face 8a of multilayers 8, and 8a, it was difficult for them to carry out magnetic association of the ferromagnetic layers 9 and 9 and the free magnetic layer 6 by Joints J and J, and they were difficult to change the free magnetic layer 6 into the single domain-ized condition stabilized in the direction of X also from this reason.

[0012] In addition, if the tilt angle theta 1 of the side faces 8a and 8a of multilayers 8 is made small in order to stabilize magnetic association with the ferromagnetic layers 9 and 9 and the free magnetic layer 6 by Joints J and J, it will become difficult to form the dimension of the truck cross direction (the direction of X) of the free magnetic layer 6 within the limits of predetermined.

[0013] Thus, in the magnetic sensing element of the exchange bias method shown in drawing 38 , the problem that it was difficult to change into the single domain-ized condition to which the vertical bias stabilized in the free magnetic layer 6 was applied and which was stabilized in the direction of X had arisen.

[0014] Furthermore, in order to join certainly the ferromagnetic layers 9 and 9 and the free magnetic layer 6 with structure like drawing 38 , it is necessary to thicken thickness of the ferromagnetic layers 9 and 9. However, if thickness of the ferromagnetic layers 9 and 9 is thickened, the problem that it becomes difficult for the one direction anisotropy field of the ferromagnetic layers 9 and 9 to become small, and to apply vertical bias stable enough to the free magnetic layer 6 will also be produced. Moreover, if thickness of the ferromagnetic layers 9 and 9 is thickened, the problem that an insensible field is made in the both ends of the free magnetic layer 6, and playback sensibility falls will also be produced.

[0015] This invention is for solving the above-mentioned conventional technical problem, and it is the manufacture approach of the magnetic sensing element of an exchange bias method, and a free magnetic layer can be changed into the single domain-ized condition stabilized in the direction of X, and it aims at offering the manufacture approach of the magnetic sensing element which can raise field detection sensitivity.

[0016]

[Means for Solving the Problem] The process at which the manufacture approach of the magnetic sensing element of this invention forms the multilayers which have the 1st antiferromagnetism layer, a fixed magnetic layer, a non-magnetic material layer, a free magnetic layer, and a non-magnetic layer on the (a) substrate, (b) Said multilayers in the field of the 1st heat treatment temperature and the 1st magnitude The process which anneals among the 1st magnetic field and fixes the magnetization direction of said fixed magnetic layer in the predetermined direction, (c) The process which forms a ferromagnetic layer and the 2nd antiferromagnetism layer on said multilayers, (d) The process in which a side face penetrates said 2nd antiferromagnetism layer and said ferromagnetic layer, and a base forms the crevice located in said non-magnetic layer, (e) When said 2nd antiferromagnetism layer anneals the multilayers by which the laminating was carried out among the 2nd magnetic field in the field of the 2nd heat treatment temperature and the 2nd magnitude, it is characterized by having the process which fixes the magnetization direction of said free magnetic layer in the magnetization direction of said fixed magnetic layer, and the crossing direction.

[0017] Since the laminating of said ferromagnetic layer and said 2nd antiferromagnetism layer is carried out in the process of the above (c) in this invention on the front face of said non-magnetic layer formed as a flat side It becomes easy to enlarge the RKKY interaction between said ferromagnetic layers and said free magnetic layers in the synthetic ferry structure where can also form said ferromagnetic layer and said 2nd antiferromagnetism layer as a layer by which flattening was carried out, and they consist of said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer.

[0018] Moreover, in this invention, since the laminating of said ferromagnetic layer and said 2nd antiferromagnetism layer is carried out on said non-magnetic layer which is a flat side, control of the laminating process of said ferromagnetic layer and said 2nd antiferromagnetism layer becomes easy. In the synthetic ferry structure which consists of said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer especially, said ferromagnetic layer can be formed thinly, and it becomes easy to enlarge the spin FUROPPU field between said ferromagnetic layers and said free magnetic layers.

[0019] Moreover, in this invention, since the magnetic material layer which is said free magnetic layer is extended and formed even in the lower layer of said 2nd antiferromagnetism layer and said ferromagnetic layer, magnetization of said free magnetic layer can make it small to be influenced [which is generated by the surface magnetic charge of the both-sides edge of said free magnetic layer] of an anti-field.

[0020] Moreover, since said multilayers are annealed among a magnetic field and the magnetization direction of said fixed magnetic layer is fixed in the predetermined direction in the condition of not carrying out the laminating of the 2nd antiferromagnetism layer, on said multilayers in this invention, where the laminating of the 2nd antiferromagnetism layer is carried out on said multilayers, the exchange anisotropy field has not occurred in said 2nd antiferromagnetism layer.
[0021] That is, the exchange anisotropy field of said 2nd antiferromagnetism layer is produced for the first time in the process of the above (e), and it becomes easy to move the magnetization direction of said free magnetic layer in the predetermined direction. Therefore, it becomes easy to fix the magnetization direction of said free magnetic layer in the magnetization direction of said fixed magnetic layer and the crossing direction.
[0022] Moreover, in the magnetic sensing element manufactured by the manufacture approach of this invention, the width of recording track is specified with the distance-across-vee dimension of said crevice. That is, the magnetization direction of a magnetic layer where the magnetization direction changes with external magnetic fields, such as said free magnetic layer, can be changed only in the part which laps with the base of said crevice. And since said crevice can form said 2nd antiferromagnetism layer formed by uniform thickness only by deleting to the perpendicular direction to the truck cross direction using reactive ion etching (RIE) or ion milling, it becomes possible to form said crevice by the exact width method. That is, the width of recording track of a magnetic sensing element can be specified correctly.
[0023] After said ferromagnetic layer has touched the top face of said non-magnetic layer, the magnetic sensing element formed of this invention opens predetermined spacing crosswise [truck], and is formed in it, and the laminating of said 2nd antiferromagnetism layer is further carried out on said ferromagnetic layer.
[0024] In the magnetic sensing element formed of this invention The magnetization direction is arranged crosswise [truck] for the ferromagnetic layer in the lower layer of said 2nd antiferromagnetism layer by magnetic association with said 2nd antiferromagnetism layer. Furthermore, the magnetization direction of the both-sides section of the free magnetic layer formed in the lower layer of this ferromagnetic layer through the non-magnetic layer is arranged with the magnetization direction and the anti-parallel direction of said ferromagnetic layer by the RKKY interaction with said ferromagnetic layer. Namely, in the lower layer of said 2nd antiferromagnetism layer, said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer have synthetic ferry structure, and the both-sides section which is the field which laps with said 2nd antiferromagnetism layer and said ferromagnetic layer of said free magnetic layer is being fixed in the direction in which the magnetization direction intersects the magnetization direction of said fixed magnetic layer.
[0025] On the other hand, the magnetization direction of the width-of-recording-track field which is a field which does not lap with said 2nd antiferromagnetism layer and said ferromagnetic layer of said free magnetic layer will change towards the height direction, if it learns from said both-sides section, the truck cross direction and an anti-parallel direction are turned to and an external magnetic field is given in the direction (the height direction) perpendicular to the truck cross direction, when it is in the condition that an external magnetic field is not given.
[0026] Electric resistance changes by the relation between fluctuation of the direction of magnetization in the width-of-recording-track field of said this free magnetic layer, and the fixed magnetization direction of said fixed magnetic layer (this is called magneto-resistive effect), and external magnetic fields, such as a leak field from a record medium, are detected by the electrical-potential-difference change based on this electric resistance value change.
[0027] In this invention, since said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer have synthetic ferry structure in the lower layer of said 2nd antiferromagnetism layer, the one direction anisotropy field for arranging the magnetization direction in the both-sides section of said free magnetic layer in the fixed direction can be enlarged.
[0028] Therefore, it can suppress that the magnetization direction of the both-sides section of said free magnetic layer changes, and the magnetic width of recording track becomes large as a result by the external magnetic field.
[0029] Moreover, even if the switched connection field of said 2nd antiferromagnetism layer and said ferromagnetic layer is comparatively weak, it becomes easy to arrange the magnetization direction of said free magnetic layer in the magnetization direction of said fixed magnetic layer and the crossing direction certainly.
[0030] Moreover, the field of the width of recording track (optical width of recording track) of the magnetic sensing element specified predetermined spacing of the truck cross direction of the base of said crevice contributes to playback of a record field substantially, and turns into a sensibility field which demonstrates a magneto-resistive effect.
[0031] That is, since the optical width of recording track of a magnetic sensing element becomes equal to the magnetic width of recording track, and an insensible field does not produce the magnetic sensing element of this invention, and it corresponds to high recording density-ization, the fall of the playback output at the time of making small the optical width of recording track Tw of a magnetic sensing element can be suppressed.
[0032] Moreover, since the magnitude of the bias field impressed to said free magnetic layer and the magnetic

moment (Msxt) per unit area of said free magnetic layer become equal, it becomes a magnetic high power sensing element by high sensitivity.
[0033] Moreover, in this invention, since the magnetic material layer which is said free magnetic layer is extended and formed even in the lower layer of said 2nd antiferromagnetism layer and said ferromagnetic layer, magnetization of said free magnetic layer can make it small to be influenced [which is generated by the surface magnetic charge of the both-sides edge of said free magnetic layer] of an anti-field.
[0034] moreover -- this invention -- instead of [of the process of the above (d)] -- (f) -- you may have the process at which a base forms in said 2nd antiferromagnetism layer the crevice located in said 2nd antiferromagnetism layer.
[0035] In the magnetic sensing element formed by the manufacture approach of a magnetic sensing element of having the aforementioned (f) process, instead of the aforementioned (d) process, it is located in said 2nd antiferromagnetism layer, said free magnetic layer and said ferromagnetic layer adjoin through said non-magnetic layer, and the base of said crevice will be in the ferrimagnetism condition that the magnetization direction of said free magnetic layer and the magnetization direction of said ferromagnetic layer serve as anti-parallel.
[0036] At this time, the multilayers which consist of said free magnetic layer, said non-magnetic layer, and said ferromagnetic layer function as one free magnetic layer and a so-called synthetic ferry free magnetic layer. In a synthetic ferry free magnetic layer, effectiveness equivalent to making thickness of said free magnetic layer thin is acquired, it becomes easy to change magnetization of a free magnetic layer, and the field detection sensitivity of a magneto-resistive effect component improves. In addition, the magnitude of the magnetic moment per unit area of said free magnetic layer and said ferromagnetic layer needs to differ. The magnitude of the magnetic moment per unit area of said free magnetic layer and a ferromagnetic layer is expressed with the saturation magnetization (Ms) of said ferromagnetic ingredient layer, and the product of thickness (t).
[0037] In addition, in the field of said 2nd antiferromagnetism layer located in the lower part of the base of said crevice, when thickness of the field of said 2nd antiferromagnetism layer located in the lower part of the base of said crevice is made into 50A or less more greatly than 0A, since a switched connection field does not occur between said ferromagnetic layers, it is desirable.
[0038] Moreover, in this invention, instead of the process of the above (d), the (g) side face may penetrate said 2nd antiferromagnetism layer, and you may have the process in which a base forms the crevice located in said ferromagnetic layer.
[0039] The multilayers which consist of said free magnetic layer, said non-magnetic layer, and said ferromagnetic layer also by the magnetic sensing element formed by the manufacture approach of a magnetic sensing element of having the aforementioned (g) process, instead of the aforementioned (d) process function as one free magnetic layer and a so-called synthetic ferry free magnetic layer. In this invention, the 2nd antiferromagnetism layer does not exist in the upper layer of the width-of-recording-track field where the magnetization direction changes with external magnetization of said free magnetic layer at all. Therefore, fluctuation of an external magnetic field dependency of the magnetization direction of the width-of-recording-track field of a free magnetic layer can be made sharp, and the field detection sensitivity of a magnetic sensing element can be improved.
[0040] Furthermore, it is able to make the side face of said crevice to become a vertical plane to the truck cross direction in this invention. That is, since the 2nd antiferromagnetism layer generates antiferromagnetism in all the fields from which it separated from a width-of-recording-track field, it can have sufficient thickness, and in all the fields from which it separated from the width-of-recording-track field, the magnetization direction of said free magnetic layer can certainly be fixed.
[0041] Therefore, the magnetization direction of said free magnetic layer can be moved only in the width-of-recording-track field of a magnetic sensing element, and side leading in the circumference of a width-of-recording-track field can be prevented.
[0042] In addition, in this invention, the magnetic sensing element to which a current flows in the parallel direction can be formed to the film surface of each class of said multilayers on said 2nd antiferromagnetism layer by having the process which opens spacing crosswise [truck] and carries out the laminating of the electrode layer of a pair.
[0043] In this invention, in the process of the above (d), (f), or (g), spacing can be opened crosswise [truck] on said 2nd antiferromagnetism film, the laminating of the electrode layer of a pair can be carried out, and a distance-across-vee dimension can form a crevice equal to the width of recording track by deleting the part across which the electrode layer of said pair of said 2nd antiferromagnetism layer faced.
[0044] Thus, if said crevice is deleted by using the electrode layer of said pair as a mask, the side edge side by the side of the width-of-recording-track field of said electrode layer can form the magnetic sensing element used as the side edge side by the side of said width-of-recording-track field of said 2nd antiferromagnetism layer, and a continuation side.
[0045] Or in this invention, in the process of the above (d), (f), or (g), spacing of the width of recording track can be opened on said 2nd antiferromagnetism layer, the laminating of the 1st resist layer of a pair can be carried out,

and a crevice can be formed by deleting the part across which said 1st resist layer of said 2nd antiferromagnetism layer faced.
[0046] Furthermore, the process which is the inside of the (h) aforementioned crevice, and on said 2nd antiferromagnetism layer, and forms the 2nd resist layer on the outskirts of opening of said crevice after forming said crevice and removing said 1st resist layer, (i) You may have the process which forms an electrode layer to the field which is not covered with said resist layer on said 2nd antiferromagnetism layer, and the process which removes the resist layer of the (j) above 2nd.
[0047] By forming an electrode layer by using as a mask the 2nd resist layer formed at the aforementioned (h) process, after forming said crevice by using said 1st resist layer as a mask in the aforementioned (d) process The side edge edge by the side of the width-of-recording-track field of said electrode layer can form the magnetic sensing element currently formed in the heel side of said multilayers rather than the side edge edge by the side of said width-of-recording-track field of said 2nd antiferromagnetism layer.
[0048] The up shielding layer and lower shielding layer to which the magnetic sensing element formed of this invention becomes the upper layer and lower layer from a magnetic material through the gap layer which consists of an insulating ingredient can be formed.
[0049] If the side edge edge by the side of the width-of-recording-track field of said electrode layer is formed in the heel side of said multilayers, it can make more gently-sloping than the side edge edge by the side of said width-of-recording-track field of said 2nd antiferromagnetism layer the level difference which the top face of the top face of the width-of-recording-track field of said non-magnetic layer, said electrode layer, and said 2nd antiferromagnetism layer builds. Therefore, even if it makes small thickness of said gap layer of the upper layer of a magnetic sensing element, said gap layer can be certainly formed on this level difference. Namely, the electric short circuit between said up shielding layer and said electrode layer, said 2nd antiferromagnetism layer, and said ferromagnetic layer can be prevented more certainly, and it can respond now to narrow gap-ization.
[0050] Moreover, if the distance between said up shielding layer [/ near the both sides of the width-of-recording-track field of said multilayers] and said lower shielding layer becomes large, it will pass along between said up shielding layer and said lower shielding layers, the field from the record medium generated from the recording track of the both sides of the recording track for detection will become easy to invade into a magnetic sensing element, and the effective width of recording track will become large. That is, it becomes easy to generate the cross talk between recording tracks.
[0051] In this invention, since the level difference which the top face of the top face of the width-of-recording-track field of said non-magnetic layer, said electrode layer, and said 2nd antiferromagnetism layer builds can be made gently-sloping as mentioned above, it can suppress that the distance between said up shielding layer [/ near the both sides of said multilayers] and said lower shielding layer becomes large, and the effective width of recording track can be made small.
[0052] Or after forming said crevice in the process of the above (d), (f), or (g) and removing said 1st resist layer in this invention (k) The process at which the width method of the truck cross direction at the bottom forms the 2nd resist layer smaller than the distance-across-vee dimension of said 1st resist layer on the base of said crevice, (l) You may have the process which applies on said 2nd antiferromagnetism layer from the inside of said crevice, and forms an electrode layer, and the process which removes the resist layer of the (m) above 2nd.
[0053] By forming an electrode layer by using as a mask the 2nd resist layer formed at the aforementioned (k) process, after forming said crevice by using said 1st resist layer as a mask in the above (d), (f), or the (g) process The laminating of said electrode layer is carried out on said 2nd antiferromagnetism layer, and the side edge edge by the side of the width-of-recording-track field of said electrode layer can form the magnetic sensing element which is extended and is formed in the center-section side of said multilayers rather than the side edge edge by the side of said width-of-recording-track field of said ferromagnetic layer and said 2nd antiferromagnetism layer.
[0054] Said ferromagnetic layer and said 2nd antiferromagnetism layer are formed with an ingredient with large specific resistance compared with said electrode layer. If the laminating of said electrode layer is carried out only on said ferromagnetic layer and said 2nd antiferromagnetism layer, the direct current supplied to said electrode layer will flow through said ferromagnetic layer and said 2nd antiferromagnetism layer to said non-magnetic layer, said free magnetic layer, said non-magnetic material layer, and a fixed magnetic layer, and the direct-current-resistance value of a magnetic sensing element will become large.
[0055] If the side edge edge by the side of the width-of-recording-track field of said electrode layer is extended at the center-section side of said multilayers rather than the side edge edge by the side of said width-of-recording-track field of said ferromagnetic layer and said 2nd antiferromagnetism layer The side edge edge by the side of the width-of-recording-track field of said electrode layer is extensible even on said non-magnetic layer, and since the direct current supplied to said electrode layer can be passed without minding said ferromagnetic layer and said 2nd antiferromagnetism layer, the direct-current-resistance value of a magnetic sensing element can be made small.
[0056] Moreover, since the width of recording track Tw of a magnetic sensing element will be prescribed by the

distance between side edge edges by the side of the width-of-recording-track field of the electrode layer of a pair if the side edge edge by the side of the width-of-recording-track field of said electrode layer is extended even on said non-magnetic layer When the presentation of said 2nd antiferromagnetism layer changes in the field near the side edge side by the side of the width-of-recording-track field of the 2nd antiferromagnetism layer or who arises Even if it becomes easy to move the magnetization direction side edge sections [of the free magnetic layer 17 / 17s and 17s] near a width-of-recording-track field, it can suppress that the width of recording track Tw changes.
[0057] In addition, in this invention, the magnetic sensing element of the CPP (current perpendicular to theplane) mold with which an electrode layer is prepared up and down, and a current flows perpendicularly to the film surface of each class of said multilayers of said multilayers can be formed.
[0058] When forming the magnetic sensing element of a CPP mold, it is required before the aforementioned (a) process to have the process which forms a lower electrode layer on the (n) substrate, and it is still more desirable to have the following processes instead of the process of the above (d), (f), or (g). (o) the process which forms an insulating layer on said 2nd antiferromagnetism layer, and (p) -- the process which forms a crevice on said insulating layer by deleting the part which carried out the laminating of the resist which prepared the hole crosswise [truck] in the center section, and was exposed to said hole of said insulating layer and said 2nd antiferromagnetism layer, and (q) -- the process which forms in the base of said crevice the up electrode layer which flows electrically.
[0059] In this invention, splitting of the sense current from said up electrode layer to said 2nd antiferromagnetism layer can be reduced by preparing said insulating layer on said 2nd antiferromagnetism layer.
[0060] Moreover, since a part of up electrode layer can form the lobe projected in said direction of multilayers in the center of the truck cross direction of said up electrode layer by entering into said crevice, the current path of a sense current can be narrowed down and improvement in an output and reduction of side leading can be aimed at.
[0061] moreover, between the aforementioned (p) process and the aforementioned (q) processes -- (r) -- the process which applies on said insulating layer from said crevice, and forms other insulating layers, and (s) -- the laminating was carried out on the base of said crevice -- said -- others -- if it has the process which removes an insulating layer, since the insulation between the side face of said crevice and said up electrode layer can also be taken, it is desirable.
[0062] Moreover, the aforementioned (n) process and the process which forms the lobe projected in said direction of multilayers in the center of the truck cross direction of the (t) aforementioned lower electrode layer between the aforementioned (a) processes, (u) Have the process which prepares an insulating layer in the both-sides section of the truck cross direction of said lobe of said lower electrode layer, and it sets at the aforementioned (a) process. Since the current path of a sense current can be narrowed down and improvement in an output and reduction of side leading can be aimed at if said multilayers are formed so that the top face of said lobe may touch the inferior surface of tongue of said multilayers, it is desirable.
[0063] In addition, in the aforementioned (u) process, if the top face of said lobe and the top face of said insulating layer prepared on the both-sides edge of said lower electrode layer are made into the same flat surface, since said multilayers can be formed on a flat side, it is desirable.
[0064] Moreover, moreover the structure of a magnetic sensing element will become simple and manufacture will become easy since said lower electrode layer and/or said up electrode layer can be operated as shielding layers if said lower electrode layer and/or said up electrode layer are formed with a magnetic material, since gap length can be shortened and the magnetic sensing element which can respond can be manufactured suitable for a raise in recording density, it is desirable.
[0065] Furthermore, if the base of said crevice, the layer formed with the nonmagnetic conductivity ingredient which flows electrically, and the layer formed with a magnetic material make said up electrode layer that by which the laminating was carried out, the magnetic effect on [from the layer formed with the magnetic material of said up electrode layer] said free magnetic layer can be reduced.
[0066] Moreover, it is desirable to form said non-magnetic material layer with a nonmagnetic electrical conducting material in this invention. Said non-magnetic material layer is calling the magnetic sensing element formed with the nonmagnetic electrical conducting material the spin bulb GMR mold magneto-resistive effect component (CPP-GMR).
[0067] Moreover, by this invention, when it is the magnetic sensing element of a CPP mold, said non-magnetic material layer may be formed by the insulating material. This magnetic sensing element is called the spin bulb tunnel mold magneto-resistive effect mold component (CPP-TMR).
[0068] In addition, it is desirable to set the 2nd heat treatment temperature as temperature lower than the blocking temperature of the 1st antiferromagnetism layer, and to make magnitude of the 2nd field smaller than the exchange anisotropy field of the 1st antiferromagnetism layer in the process of the above (e), in this invention.
[0069] In addition, at the process of the above (a), if said non-magnetic layer is formed with a conductive ingredient, it can function as a BAKKUDO layer which has the spin filter effectiveness which said non-magnetic layer mentions later, and the field detection sensitivity of a magnetic sensing element can be raised.

[0070] Since the front face of said non-magnetic layer will hardly oxidize in the aforementioned (b) process if it forms with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os, said non-magnetic layer is desirable. Therefore, in the aforementioned (d) process, before carrying out spatter membrane formation of said ferromagnetic layer on said non-magnetic layer, even if it does not process the front face of said non-magnetic layer by milling etc., the RKKY interaction which minded said non-magnetic layer between said free magnetic layers and said ferromagnetic layers can be used.

[0071] That is, since according to the manufacture approach of the magnetic sensing element of this invention it can end even if it does not make the interface of said non-magnetic layer and said ferromagnetic layer into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the magnetization direction in the both-sides section of said free magnetic layer in the fixed direction can be prevented.

[0072] However, in this invention, said ferromagnetic layer and said free magnetic layer can obtain the one direction anisotropy field of sufficient magnitude to arrange the magnetization direction in the both-sides section of said free magnetic layer in the fixed direction, even when the interface of said non-magnetic layer and said ferromagnetic layer is made into the field processed by milling, since it is magnetically combined by the RKKY interaction through said non-magnetic layer.

[0073] Since said non-magnetic layer can carry out greatly the RKKY interaction between the both-sides sections of said ferromagnetic layer and said free magnetic layer to it being formed of Ru and thickness being 0.8-1.1nm, it is desirable. Said non-magnetic layer is especially formed of Ru, and it is more desirable that thickness is 0.85-0.9nm.

[0074] Moreover, in the process of the above (a), if the conductive ingredient layer which specific resistance becomes from a conductive ingredient lower than said non-magnetic layer between said non-magnetic layers and said free magnetic layers is formed, since it can do now the bigger spin filter effectiveness than the case of only said non-magnetic layer so and the field detection sensitivity of a magnetic sensing element can be raised further, it is desirable.

[0075] When forming said conductive ingredient layer, said non-magnetic layer can be formed by Ru as that whose thickness is 0.4-1.1nm, for example, and said conductive ingredient layer can be further formed by Cu as that whose thickness is 0.3-0.5nm.

[0076] If said non-magnetic layer by which the laminating was carried out in contact with the top face of said free magnetic layer is formed with the conductive ingredient or said conductive ingredient layer is formed between said non-magnetic layers and said free magnetic layers, it will become possible to operate said non-magnetic layer as a BAKKUDO layer (backedlayer) which has the spin filter effectiveness.

[0077] If a sense current is impressed to a spin bulb mold MAG sensing element, conduction electron will move near [where electric resistance is mainly small] a non-magnetic material layer. Two kinds of electrons, rise spin and down spin, recognize equivalent existence probable at this conduction electron.

[0078] The magnetic-reluctance rate of change of a spin bulb mold MAG sensing element shows forward correlation to the stroke difference of the mean free path of two kinds of these conduction electron.

[0079] Irrespective of the sense of the external magnetic field impressed, it is always scattered about by the interface of a non-magnetic material layer and a free magnetic layer, the probability which moves to a free magnetic layer is maintained while it has been low, and the mean free path is still short about the conduction electron of down spin, compared with the mean free path of the conduction electron of rise spin.

[0080] On the other hand, about the conduction electron of rise spin, when the magnetization direction of a free magnetic layer changes into the magnetization direction and parallel condition of a fixed magnetic layer by the external magnetic field, the probability which moves to a free magnetic layer from a non-magnetic material layer becomes high, and the mean free path is long. On the other hand, the probability scattered about by the interface of a non-magnetic material layer and a free magnetic layer increases, and the mean free path of the conduction electron of rise spin becomes short as the magnetization direction of a free magnetic layer changes with external magnetic fields from an parallel condition to the magnetization direction of a fixed magnetic layer.

[0081] Thus, the mean free path of the conduction electron of rise spin changes a lot compared with the mean free path of the conduction electron of down spin, and a stroke difference changes with operations of an external magnetic field a lot. Then, the resistance as the whole component expressed as a parallel circuit of the resistance which a rise spin electron receives, and the resistance which a down spin electron receives also changes a lot, and the magnetic-reluctance rate of change (deltaR/R) of a spin bulb mold MAG sensing element becomes large.

[0082] Here, if a BAKKUDO layer is connected to a free magnetic layer, the conduction electron of rise spin which moves in the inside of a free magnetic layer is enabled to move even into a BAKKUDO layer, and it can develop further the mean free path of the conduction electron of rise spin in proportion to the thickness of a BAKKUDO layer. For this reason, it can become possible to make the so-called spin filter effectiveness discover, the stroke difference of the mean free path of conduction electron can become large, and the magnetic-reluctance rate of change (deltaR/R) of a spin bulb mold MAG sensing element can be raised more.

[0083] It is desirable to be set as the range whose thickness of said free magnetic layer is 1.5-4.5nm in this invention.
[0084] The expansion of the mean free path difference of the conduction electron of rise spin and the conduction electron of down spin by the spin filter effectiveness demonstrates effectiveness by the case where the thickness of a free magnetic layer is comparatively thin.
[0085] It cannot become difficult to form so that it may function as the thickness of a free magnetic layer being thinner than 1.5nm as a ferromagnetic ingredient layer, and sufficient magneto-resistive effect cannot be acquired. Moreover, since the conduction electron which carries out the usual dispersion (diffusive scattering), without carrying out specular reflection (specular reflection) also exists, and resistance rate of change falls, it is not desirable.
[0086] Moreover, it is not desirable in order that the rate that the conduction electron of the rise spin scattered about before reaching said non-magnetic layer, if the thickness of a free magnetic layer is thicker than 4.5nm increases, and resistance rate of change changes with spin filter effectiveness may decrease.
[0087] It is desirable to carry out the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs said fixed magnetic layer through a nonmagnetic interlayer in the process of the above (a) in this invention, and to consider as the ferrimagnetism condition that the magnetization direction of said ferromagnetic ingredient layer which adjoins through said nonmagnetic interlayer serves as anti-parallel.
[0088] If a fixed magnetic layer is formed as a nonmagnetic interlayer's thing to which the laminating of the ferromagnetic ingredient layer was carried out up and down, the ferromagnetic ingredient layer of these two or more layers can fix the mutual magnetization direction, and can suit, and the magnetization direction of a fixed magnetic layer can be powerfully fixed in the fixed direction as a whole. That is, the switched connection field Hex of the 2nd antiferromagnetism layer and a fixed magnetic layer can be acquired as a big value.
[0089] Moreover, the anti-field (dipole field) by fixed magnetization of a fixed magnetic layer is cancellable when static magnetic field association of a two or more layers ferromagnetic ingredient layer negates each other mutually. Thereby, the contribution to the fluctuation magnetization of a free magnetic layer from the anti-field (dipole field) by fixed magnetization of a fixed magnetic layer can be decreased.
[0090] Therefore, it becomes easier to amend the direction of fluctuation magnetization of a free magnetic layer towards desired, and it becomes possible to obtain the magnetic sensing element which was excellent in symmetric property with small asymmetry.
[0091] Here, when asymmetry shows the asymmetric degree of a playback output wave and a playback output wave is given, asymmetry will become small if the wave is symmetrical. Therefore, the playback output wave will be excellent in symmetric property, so that asymmetry approaches 0.
[0092] Said asymmetry is set to 0 when the direction of fluctuation magnetization of a free magnetic layer and the direction of fixed magnetization of a fixed magnetic layer lie at right angles. If asymmetry shifts greatly, reading of the information from media will become impossible correctly, and will cause an error. For this reason, the dependability of regenerative-signal processing will improve as a thing with said small asymmetry, and it becomes what was excellent as a spin bulb MAG sensing element.
[0093] Moreover, although the anti-field (dipole field) Hd by fixed magnetization of a fixed magnetic layer has uneven distribution that it is large and small in the center section, at the edge in the component height direction of said free magnetic layer and single domain-ization in a free magnetic layer may be barred It can prevent that can set the dipole field Hd to Hd=0 mostly, and a magnetic domain wall is made in a free magnetic layer by this, the ununiformity of magnetization occurs, and a Barkhausen noise etc. occurs by making a fixed magnetic layer into the above-mentioned laminated structure.
[0094] Moreover, since the effectiveness same with carrying out the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs said free magnetic layer through a nonmagnetic interlayer in the process of the above (a) in this invention, carrying out thickness of said free magnetic layer to it being in the ferrimagnetism condition that the magnetization direction of said ferromagnetic ingredient layer which adjoins through said nonmagnetic interlayer serves as anti-parallel thinly, and raising field detection sensitivity is acquired, it is desirable.
[0095] In addition, the magnitude of the magnetic moment per unit area of said ferromagnetic ingredient layer is expressed with the saturation magnetization (Ms) of said ferromagnetic ingredient layer, and the product of thickness (t).
[0096] Said nonmagnetic interlayer can be formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Os, Cr, Re, and Cu.
[0097] Moreover, it is desirable to form at least one side in this invention using the magnetic material which has the following presentations among said ferromagnetic layers and said free magnetic layers.
[0098] It is the magnetic material whose remaining presentation ratios an empirical formula is shown by CoFeNi,

the presentation ratio of Fe is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and are Co(es).
[0099] Moreover, it is desirable to form the interlayer who consists of a CoFe alloy or Co between said free magnetic layers and said non-magnetic material layers in this invention.
[0100] When said interlayer is formed, it is desirable to form at least one side using the magnetic material which has the following presentations among said ferromagnetic layers and said free magnetic layers. It is the magnetic material whose remaining presentation ratios an empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 15 atom % above 7 atom %, the presentation ratio of nickel is below 15 atom % above pentatomic %, and are Co(es).
[0101] It is desirable to form both said ferromagnetic layer and said free magnetic layer by said CoFeNi in this invention.
[0102] By the way, in this invention, in the lower layer of said 2nd antiferromagnetism layer, said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer are laminating ferry structures, and it is in the ferrimagnetism condition that the magnetization direction of said ferromagnetic layer and free magnetic layer which adjoins through said non-magnetic layer serves as anti-parallel.
[0103] In order to keep this anti-parallel magnetization condition suitable, there is the need of enlarging the switched connection field in the RKKY interaction which improves the quality of the material of said ferromagnetic layer and said free magnetic layer, and is committed between said ferromagnetic layers and said free magnetic layers.
[0104] A NiFe alloy is one of those which are often used as a magnetic material which forms said ferromagnetic layer and said free magnetic layer. Since a NiFe alloy was excellent in soft magnetic characteristics, it was used for the free magnetic layer etc. from the former, but when said ferromagnetic layer and said free magnetic layer are made into laminating ferry structure using a NiFe alloy, the anti-parallel bonding strength between these layers is not so strong.
[0105] So, in this invention, the quality of the material of said ferromagnetic layer and said free magnetic layer is improved. The anti-parallel bonding strength between said ferromagnetic layers and said free magnetic layers is made for the both-sides edge of the free magnetic layer located in the both sides of strength and the truck cross direction not to swing to an external magnetic field. At least on the other hand, the thing of the generating of side leading is preferably done to both among said ferromagnetic layers and said free magnetic layers using the CoFeNi alloy to enable it to control appropriately. The above-mentioned anti-parallel bonding strength can be strengthened by making Co contain.
[0106] Drawing 18 is the conceptual diagram of the so-called hysteresis loop of the laminating ferry structure which carried out the laminating of the thin film which consists of a ferromagnetic ingredient through the non-magnetic material layer. For example, the magnetic moment (saturation magnetization Msx thickness t) per unit area of the 1st ferromagnetic ingredient layer (F1) presupposes that it is larger than the magnetic moment per unit area of the 2nd ferromagnetic ingredient layer (F2). Moreover, suppose that the external magnetic field was given rightward [illustration].
[0107] The synthetic magnetic moment per [for which it can ask by the vector sum (|Ms-t(F1) +Ms-t(F2) |) of the magnetic moment per unit area of the 1st ferromagnetic ingredient layer and the magnetic moment per unit area of the 2nd ferromagnetic ingredient layer] unit area is fixed magnitude till the time also of having also enlarged the external magnetic field from zero field. In the external magnetic field field A whose synthetic magnetic moment per this unit area is fixed magnitude, since the anti-parallel bonding strength committed between said 1st ferromagnetic ingredient layer and the 2nd ferromagnetic ingredient layer is stronger than said external magnetic field, magnetization of said 1st and 2nd ferromagnetic ingredient layers is single-domain-ized appropriately, and is maintained at the anti-parallel condition.
[0108] However, if the external magnetic field to the illustration right is enlarged further, the synthetic magnetic moment per unit area of a ferromagnetic ingredient layer has a tilt angle, and becomes large. Magnetization of the 1st ferromagnetic ingredient layer single-domain-ized since said external magnetic field was stronger than the anti-parallel bonding strength committed between said 1st ferromagnetic ingredient layer and the 2nd ferromagnetic ingredient layer, and the 2nd ferromagnetic ingredient layer distributes, this will be in a many magnetic-domains-ized condition, and the synthetic magnetic moment per [for which it can ask by the vector sum] unit area will become large. In the external magnetic field field B in which the synthetic magnetic moment per this unit area becomes large, the anti-parallel condition of said ferromagnetic ingredient layer is already in the condition of having collapsed. The magnitude of the external magnetic field of the starting point where the synthetic magnetic moment per this unit area begins to become large is called the spin FUROPPU field (Hsf).
[0109] If the external magnetic field of the illustration right is furthermore enlarged, magnetization of the 1st ferromagnetic ingredient layer and the 2nd ferromagnetic ingredient layer will be single-domain-ized again, unlike the case of the external magnetic field field A, it will be magnetized rightward [illustration] shortly [both], and

the synthetic magnetic moment per unit area in this external magnetic field field C will serve as constant value. The magnitude of the external magnetic field in the time of the synthetic magnetic moment per this unit area serving as constant value is called the saturation field (Hs).
[0110] When said CoFeNi alloy was used for the 1st ferromagnetic ingredient layer and the 2nd ferromagnetic ingredient layer, it turned out that a field in case an anti-parallel condition collapses compared with the case where a NiFe alloy is used, and the so-called spin FUROPPU field (Hsf) can be enlarged enough.
[0111] The experiment for asking for the magnitude of the spin FUROPPU field which used and described above the NiFe alloy (example of a comparison) and the CoFeNi alloy (example) in the 1st and 2nd ferromagnetic ingredient layers was conducted using the following film configurations.
[0112] A substrate / non-magnetic material layer (Cu) / the 1st ferromagnetic ingredient layer (2.4) / non-magnetic layer (Ru) / 2nd ferromagnetic ingredient layer (1.4). In addition, parenthesis writing shows thickness and a unit is nm.
[0113] The presentation ratio of nickel used the NiFe alloy with which the presentation ratio of Fe consists of 20 atoms % by 80 atom % for the 1st ferromagnetic ingredient layer in the example of a comparison, and the 2nd ferromagnetic ingredient layer. The spin FUROPPU field (Hsf) at this time was about 59 (kA/m).
[0114] Next, the presentation ratio of Co used the CoFeNi alloy with which the presentation ratio of Fe consists by 87 atom %, and the presentation ratio of nickel consists of two atoms % by 11 atom % for the 1st ferromagnetic ingredient layer in an example, and the 2nd ferromagnetic ingredient layer. The spin FUROPPU field (Hsf) at this time was about 293 (kA/m).
[0115] Thus, it turned out using the NiFe alloy that rather than can raise [which uses a CoFeNi alloy] a spin FUROPPU field effectively at the 1st ferromagnetic ingredient layer and the 2nd ferromagnetic ingredient layer.
[0116] That is, if a CoFeNi alloy is preferably used for both at least on the other hand among said ferromagnetic layers and said free magnetic layers, the spin FUROPPU field of said ferromagnetic layer and said free magnetic layer can be raised effectively.
[0117] Next, the presentation ratio of a CoFeNi alloy is explained. The case where a NiFe alloy is used because a CoFeNi alloy touches Ru layer which is a non-magnetic layer shows that magnetostriction shifts to an about 1x6-6 to 6x10 to 6, and forward side.
[0118] As for said magnetostriction, it is desirable that it is within the limits of -3x10-6 to 3x10-6. Moreover, as for coercive force, it is desirable that it is below 790 (A/m). When magnetostriction is large, since it becomes easy to be influenced according to a membrane formation strain, the difference of the coefficient of thermal expansion between other layers, etc. of stress, the low thing of said magnetostriction is desirable. Moreover, it is desirable that coercive force is low and it can make good flux reversal to the external magnetic field of a free magnetic layer by this.
[0119] When formed in this invention with the film configuration of a non-magnetic material layer / free magnetic layer / non-magnetic layer / ferromagnetic layer, Fe presentation ratio of said CoFeNi is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and, as for the remaining presentation ratios, it is desirable that it is Co. If the presentation ratio of Fe becomes larger than 17 atom %, while magnetostriction becomes larger to negative than -3x10-6, soft magnetic characteristics are degraded and it is not desirable.
[0120] Moreover, it causes degradation of soft magnetic characteristics and is not desirable while magnetostriction will become larger than 3x10-6, if the presentation ratio of Fe becomes smaller than 9 atom %.
[0121] Moreover, if the presentation ratio of nickel becomes larger than 10 atom %, while magnetostriction will become larger than 3x10-6, it causes decline in the resistance variation (deltaR) by diffusion of nickel etc., and resistance rate of change (deltaR/R) and is not desirable between non-magnetic material layers.
[0122] Moreover, if the presentation ratio of nickel becomes smaller than 0.5 atom %, magnetostriction becomes [negative] large and is not more desirable than -3x10-6.
[0123] Moreover, coercive force can be made below into 790 (A/m) if it is above-mentioned presentation within the limits.
[0124] When forming the interlayer who consists of a CoFe alloy or Co said free magnetic layer, said non-magnetic material layer, and in between, next, specifically For example, when formed with the film configuration of a non-magnetic material layer / interlayer (CoFe alloy) / free magnetic layer / non-magnetic layer / ferromagnetic layer, Fe presentation ratio of said CoFeNi is below 15 atom % above 7 atom %. The presentation ratio of nickel is below 15 atom % above pentatomic %, and, as for the remaining presentation ratios, it is desirable that it is Co. If the presentation ratio of Fe becomes larger than 15 atom %, while magnetostriction becomes larger to negative than -3x10-6, soft magnetic characteristics are degraded and it is not desirable.
[0125] Moreover, it causes degradation of soft magnetic characteristics and is not desirable while magnetostriction will become larger than 3x10-6, if the presentation ratio of Fe becomes smaller than 7 atom %.
[0126] Moreover, if the presentation ratio of nickel becomes larger than 15 atom %, magnetostriction becomes

large and is not more desirable than 3x10-6.
[0127] Moreover, if the presentation ratio of nickel becomes smaller than pentatomic %, magnetostriction becomes [negative] large and is not more desirable than -3x10-6.
[0128] Moreover, coercive force can be made below into 790 (A/m) if it is above-mentioned presentation within the limits.
[0129] In addition, since the interlayer formed by CoFe or Co has minus magnetostriction, compared with the case of the film configuration between which said interlayer is not made to intervene between the 1st free magnetic layer and a non-magnetic material layer, he lessens Fe presentation of a CoFeNi alloy a little, and makes [many / a little] nickel presentation.
[0130] Moreover, diffusion of the metallic element between a free magnetic layer and a non-magnetic material layer can be more effectively prevented by making the interlayer who consists of a CoFe alloy or Co intervene between a non-magnetic material layer and a free magnetic layer like the above-mentioned film configuration, and it is desirable.
[0131] In addition, with the gestalt of this operation, even if it forms said 1st antiferromagnetism layer and said 2nd antiferromagnetism layer using the antiferromagnetism ingredient of the same presentation It can become possible easily to make the magnetization direction of said 1st antiferromagnetism layer and the magnetization direction of said 2nd antiferromagnetism layer cross, and the magnetization direction of said free magnetic layer and said fixed magnetic layer can be made to cross in the condition that the external magnetic field is not impressed.
[0132] As for said 1st antiferromagnetism layer and/or said 2nd antiferromagnetism layer, being formed with the PtMn alloy is desirable. Or said antiferromagnetism layer is X-Mn (however, X). It is the alloy which are any one sort or two sorts or more of elements of Pd, Ir, Rh, Ru, Os, nickel, and Fe, or is Pt-Mn-X' (however, X'). It can be formed with the alloy which are any one sort or two sorts or more of elements of Pd, Ir, Rh, Ru, Au, Ag, Os, Cr, nickel, Ar, Ne, Xe, and Kr.
[0133] Here, in the alloy shown by said PtMn alloy and the formula of said X-Mn, it is desirable that the range of Pt or X is 37 - 63at%. Unless it specifies especially, the upper limit and minimum of the numerical range shown by - mean the above hereafter.
[0134] Moreover, in the alloy shown by the formula of Pt-Mn-X', it is desirable that the range of X'+Pt is 37 - 63at%. Furthermore, in the alloy shown by the formula of said Pt-Mn-X', it is desirable that the range of X' is 0.2 - 10at%. However, when X' is any one sort or two sorts or more of elements of Pd, Ir, Rh, Ru, Os, nickel, and Fe, as for X', it is desirable that it is the range of 0.2 - 40at%.
[0135] The 1st antiferromagnetism layer and the 2nd antiferromagnetism layer which generate a big switched connection field can be obtained by using the alloy of these suitable presentation range and heat-treating this as the 1st antiferromagnetism layer and the 2nd antiferromagnetism layer. Especially, if it is a PtMn alloy, it has a switched connection field exceeding 48 or more kA/m, for example, 64 kA/m, and the blocking temperature which loses said switched connection field can obtain 380 degrees C, the outstanding, very high 1st antiferromagnetism layer, and the 2nd antiferromagnetism layer.
[0136] In the condition immediately after membrane formation, although these alloys are the face centered cubic structures (fcc) of an irregular system, they carry out a structure transformation by heat treatment at the face-centered square structure (fct) of a CuAuI type rule mold.
[0137] In addition, it is desirable to perform the process of the above (a) in the same vacuum membrane formation equipment.
[0138]
[Embodiment of the Invention] It is process drawing for drawing 5 to explain the manufacture approach of the magnetic sensing element of the gestalt operation of the 1st of this invention from drawing 1 , and is the sectional view which looked at the magnetic sensing element in a manufacture process from the opposed face side with a record medium.
[0139] For example, when a magnetic sensing element constitutes a surfacing type head, the laminating of the lower shielding layer is carried out through insulator layers, such as 2Oaluminum3 film, on the trailing end face of the slider of ceramic material.
[0140] At the process shown in drawing 1 , the laminating of the 1st antiferromagnetism layer 14 is carried out on the substrate layer 13. Continuation membrane formation of the multilayers A1 by which the laminating of the fixed magnetic layer 15 of the synthetic ferry PINDO mold which furthermore consists of 1st fixed magnetic layer 15a, nonmagnetic middle class 15b, and 2nd fixed magnetic layer 15c was carried out, and the laminating was carried out to the upper layer of the fixed magnetic layer 15 to the non-magnetic material layer 16, the free magnetic layer 17, and the non-magnetic layer 18 is carried out in the same vacuum membrane formation equipment according to thin film formation processes, such as a spatter and vacuum deposition.
[0141] The substrate layer 13 consists of Ta etc. in addition, between the substrate layer 13 and the 1st antiferromagnetism layers 14 -- or it may replace with the substrate layer 13 and a seed layer may be formed using

NiFeCr or Cr. Said seed layer is for preparing the crystal orientation of the 1st antiferromagnetism layer 14.

[0142] The 1st antiferromagnetism layer 14 A PtMn alloy, Or it is a X-Mn (however, X is one-sort [any] or two sorts or more of elements of Pd, Ir, Rh, Ru, Os, nickel, and Fe) alloy, or is Pt-Mn-X' (however, X'). It forms with the alloy which is any 1 or two or more sorts of elements of Pd, Ir, Rh, Ru, Au, Ag, Os, Cr, nickel, Ar, Ne, Xe, and Kr.

[0143] In the condition immediately after membrane formation, although these alloys are the face centered cubic structures (fcc) of an irregular system, they carry out a structure transformation by heat treatment at the face-centered square structure (fct) of a CuAuI type rule mold.

[0144] The thickness of the 1st antiferromagnetism layer 14 is 8-30nm in near the core of the truck cross direction.

[0145] As for 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c, it is desirable for it to be formed with a ferromagnetic ingredient, and to be formed with a NiFe alloy, Co, a CoNiFe alloy, a CoFe alloy, a CoNi alloy, etc., for example, to be especially formed of a NiFe alloy, a CoFe alloy, or Co. Moreover, as for 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c, being formed with the same ingredient is desirable.

[0146] Moreover, nonmagnetic interlayer 15b is formed of a non-magnetic material, and is formed among Ru, Rh, Ir, Os, Cr, Re, and Cu with one sort or these two sorts or more of alloys. Being formed especially of Ru is desirable.

[0147] The non-magnetic material layer 16 is a layer in which magnetic association with the fixed magnetic layer 15 and the free magnetic layer 17 is prevented, and a sense current mainly flows, and it is desirable to be formed of the non-magnetic material which has conductivity, such as Cu, Cr, Au, and Ag. Being formed especially of Cu is desirable.

[0148] The free magnetic layer 17 consists of diffusion prevention layer (interlayer) 17a and magnetic layer 17b. Diffusion prevention layer 17a consists of a ferromagnetic ingredient, and is formed from Co or CoFe. This diffusion prevention layer 17a is for preventing the counter diffusion of magnetic layer 17b and the non-magnetic material layer 16. Moreover, magnetic layer 17b is formed with a ferromagnetic ingredient, and is formed with a NiFe alloy, Co, a CoFeNi alloy, a CoFe alloy, a CoNi alloy, etc. In addition, the free magnetic layer 17 may be formed as a magnetic layer of a monolayer.

[0149] Moreover, when diffusion prevention layer 17a is formed like the gestalt of this operation, as for magnetic layer 17b of the free magnetic layer 17, it is desirable to form with the magnetic material which has the following presentations. The presentation ratio of Fe is the magnetic material whose presentation ratio of below 15 atom % and nickel of below 15 atom % and the remaining presentation ratios it is a CoFeNi alloy and is Co above pentatomic % above 7 atom %.

[0150] The free magnetic layer 17, the ferromagnetic layer 19, and the switched connection field in the RKKY interaction generated among 19 can be strengthened by this, and a spin FUROPPU field (Hsf) can be enlarged even about 293 (kA/m).

[0151] Moreover, magnetic layer 17b of the free magnetic layer 17 and the magnetostriction of the ferromagnetic layer 19 can be stored within the limits of -3x10-6 to 3x10-6 as it is above-mentioned presentation within the limits, and coercive force can be made small below 790 (A/m).

[0152] Furthermore, it is possible to aim at appropriately control of reduction of the resistance variation (deltaR) by improvement in the soft magnetic characteristics of the free magnetic layer 17 and nickel of magnetic layer 17b being spread in diffusion prevention layer 17a or the non-magnetic material layer 16 or resistance rate of change (deltaR/R).

[0153] In addition, when the free magnetic layer 17 is formed as a magnetic layer of a monolayer, an empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and being formed with the ferromagnetic ingredient which is Co is desirable [the free magnetic layer 17 / the remaining presentation].

[0154] A non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os. In addition, when forming a non-magnetic layer 18 by Ru, since the RKKY interaction between the ferromagnetic layer 19 and the free magnetic layer 17 can be enlarged if 0.8-1.1nm of thickness t1 of a non-magnetic layer is formed as a thing so that it may be more preferably set to 0.85-0.9nm, it is desirable.

[0155] Next, in the field of the 1st magnitude which turned to the 1st heat treatment temperature and the direction of Y for the multilayers A1 by which the laminating was carried out to the non-magnetic layer 18, 1st annealing in a magnetic field is performed, an exchange anisotropy field is generated between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a, and the magnetization direction of the fixed magnetic layer 15 is fixed in the direction of illustration Y. With the gestalt of this operation, the 1st magnitude of 270 degrees C and a field is set to 800k (A/m) for the 1st heat treatment temperature.

[0156] Next, the multilayers A2 by which carried out continuation membrane formation of the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 by the spatter as shown in drawing 2 , and the laminating was carried out from the substrate layer 13 to the 2nd antiferromagnetism layer 20 are obtained.

[0157] The same ingredient as magnetic layer 17b of the free magnetic layer 17 is used for the ingredient of the ferromagnetic layer 19. It follows, for example, is formed with a NiFe alloy, Co, a CoNiFe alloy, a CoFe alloy, a CoNi alloy, etc. An empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and, as for the remaining presentation, being formed with the ferromagnetic ingredient which is Co is [especially the ferromagnetic layer 19] desirable.
[0158] Moreover, the ingredient of the 2nd antiferromagnetism layer 20 is the same as the ingredient of the 1st antiferromagnetism layer 14.
[0159] Like the gestalt of this operation, if a non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os, in the 1st annealing in a magnetic field, the front face of a non-magnetic layer 18 will hardly oxidize. Therefore, before carrying out spatter membrane formation of the ferromagnetic layer 19 on a non-magnetic layer 18, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the RKKY interaction which minded the non-magnetic layer 18 between the free magnetic layer 17 and the ferromagnetic layer 19 can be used. For example, when both the free magnetic layer 17 and the ferromagnetic layer 19 are formed by NiFe and a non-magnetic layer 18 is formed by Ru, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the one direction anisotropy field of 42 (kA/m) can be generated.
[0160] That is, since it can end even if it does not make the interface of a non-magnetic layer 18 and the ferromagnetic layers 19 and 19 into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the magnetization direction of the free magnetic layer 17 in the fixed direction can be prevented.
[0161] However, since it is magnetically combined by the RKKY interaction through a non-magnetic layer 18, the ferromagnetic layer 19 and the free magnetic layer 17 can obtain sufficient one direction anisotropy field, in order to arrange the magnetization direction of a free magnetic layer in the fixed direction, even when the front face of a non-magnetic layer 18 is processed by milling.
[0162] Furthermore, if a non-magnetic layer 18 is formed by Ru and the free magnetic layer 17 is formed by CoFe, it is also possible to set magnetostriction of the free magnetic layer 17 to 0.
[0163] In addition, the magnetic sensing element of the gestalt of this operation can form the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation.
[0164] Next, multilayers A2 are applied to the 2nd annealing in a magnetic field in the field of the 2nd magnitude which turned to the 2nd heat treatment temperature and the direction of X, an exchange anisotropy field is generated between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and the magnetization direction of the ferromagnetic layer 19 is fixed in the direction of illustration X. With the gestalt of this operation, the 2nd magnitude of 250 degrees C and a field is set to 8 (kA/m) for the 2nd heat treatment temperature.
[0165] The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 is produced for the first time in the 2nd annealing process in a magnetic field. Therefore, the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a has been turned in the direction of illustration Y. In order to turn the exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 in the direction of illustration X What is necessary is just to set the 2nd heat treatment temperature as temperature lower than the blocking temperature to which the switched connection field by the 1st antiferromagnetism layer 14 disappears, and to make magnitude of the 2nd field smaller than the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a. Moreover, if 2nd annealing in a magnetic field is performed under these conditions, even if it forms the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 can be turned in the direction of illustration X, turning the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a in the direction of illustration Y. That is, it becomes easy to fix the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the direction which intersects perpendicularly.
[0166] In addition, the magnitude of the 2nd field at the time of the 2nd annealing in a magnetic field is larger than the anti-field of the saturation field of the free magnetic layer 17 and the ferromagnetic layer 19, the free magnetic layer 17, and the ferromagnetic layer 19, and it is desirable that it is smaller than the spin FUROPPU field in which anti-parallel association between the free magnetic layer 17 and the ferromagnetic layer 19 collapses.
[0167] Next, at the process shown in drawing 3 , the laminating of the resist layer R1 for wrap lift off is carried out for a field [a little] larger than a part for the width of recording track. It cuts deeply on the inferior surface of tongue, and section R1a and R1a are formed in the resist layer R1. In addition, although not illustrated, the protective layer which turns into the upper layer of the 2nd antiferromagnetism layer 20 from Ta, Cr, etc. may be formed.

[0168] According to the process furthermore shown in drawing 23 , the electrode layers 21 and 21 are formed in the upper layer of the 2nd antiferromagnetism layer 20. As for the spatter used with the gestalt of this operation in the case of the electrode layer 21 and membrane formation of 21, it is desirable that they are any one or more sorts of the ion beam spatter method, the long slow spatter method, or the collimation spatter method. In addition, when the protective layer formed on the 2nd antiferromagnetism layer 20 or the 2nd antiferromagnetism layer 20 of the 2nd annealing in a magnetic field oxidizes, the front face of the 2nd antiferromagnetism layer 20 or the front face of said protective layer is deleted by ion milling etc., and the part which oxidized is removed.
[0169] With the gestalt of this operation, the substrate (wafer) with which multilayers A2 were formed is perpendicularly placed to the target formed by the presentation of the electrode layers 21 and 21, and the electrode layers 21 and 21 are perpendicularly formed to the front face of said multilayers A2 because this uses the ion beam spatter method, for example.
[0170] The laminating of the sputtered particles is hard to be carried out slitting section R1a of the resist layer R1, and near R1a. Therefore, slitting section R1a of the resist layer R1, and near R1a, thickness is formed thinly and, as for the electrode layers 21 and 21, the curved-surface-like side edge sides 21a and 21a are formed in the electrode layers 21 and 21. The electrode layers 21 and 21 are formed using Au, Rh, W, Cr, Ta, etc. In addition, on the resist layer R1, layer 21b of the same presentation as the electrode layers 21 and 21 is formed. If the resist layer R1 is removed after forming the electrode layers 21 and 21, it will be in the condition which shows in drawing 4 .
[0171] As shown in drawing 5 , the part which is not covered with the electrode layers 21 and 21 of the 2nd antiferromagnetism layer 20 by using the electrode layers 21 and 21 as a mask furthermore, by ion milling or reactive ion etching (RIE) By deleting, the crevice 22 which has the width method side-face 22a penetrates the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and base 22b is located in a non-magnetic layer 18, and base 22b is equivalent to the width of recording track Tw is formed. The side faces 22a and 22a of a crevice 22 are the inclined plane or curved surface used as the side edge sides 21a and 21a of the electrode layers 21 and 21, and a continuation side. In drawing 5 , the crevice 22 is formed so that base 22b of a crevice 22 may be located in a non-magnetic layer 18.
[0172] A magnetic sensing element as formed the up gap layer 23 and the up shielding layer 24 and shown in drawing 6 can be obtained after formation of a crevice 22.
[0173] In addition, the lower shielding layer 11 and the up shielding layer 24 are formed using ferromagnetic ingredients, such as NiFe. In addition, the lower shielding layer 11 and the up shielding layer 24 may be formed of plating. Moreover, as for the lower shielding layer 11 and the up shielding layer 24, it is desirable that the direction of an easy axis has turned to the truck cross direction.
[0174] The lower gap layer 12 and the up gap layer 23 are formed with insulating ingredients, such as aluminum2O3, SiO2, and aluminum-Si-O.
[0175] With the gestalt of this operation, the laminating of the electrode layers 21 and 21 is carried out on the 2nd antiferromagnetism layer 20 and 20, and the side edge sides 21a and 21a by the side of the width-of-recording-track field C of the electrode layers 21 and 21 are the side edge sides 20a and 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layers 20 and 20, and a continuation side. Furthermore, the side edge sides 19a and 19a by the side of the width-of-recording-track field C of the ferromagnetic layers 19 and 19 are also the side edge sides 21a and 21a of the electrode layers 21 and 21 and the side edge sides 20a and 20a of the 2nd antiferromagnetism layers 20 and 20, and a continuation side.
[0176] In addition, in drawing 6 , it is equal to the sensibility field E which the width-of-recording-track field C is a field which laps with base 22b of a crevice 22, and is a field where magnetization of the free magnetic layer 17 is changed.
[0177] With the gestalt of this operation, the ferromagnetic layers 19 and 19 in the lower layer of the 2nd antiferromagnetism layers 20 and 20 The magnetization direction is arranged crosswise [truck] (the direction of illustration X) by magnetic association with the 2nd antiferromagnetism layers 20 and 20. Furthermore, the magnetization direction of the both-sides section of the free magnetic layer 17 formed in the lower layer of these ferromagnetic layers 19 and 19 through the non-magnetic layer 18 is arranged with the magnetization direction and the anti-parallel direction of the ferromagnetic layer 19 by the RKKY interaction with the ferromagnetic layers 19 and 19. Namely, in the lower layer of the 2nd antiferromagnetism layers 20 and 20, the ferromagnetic layers 19 and 19, the non-magnetic layer 18, and the free magnetic layer 17 have synthetic ferry structure, and the both-sides sections 17s and 17s which are the fields which lap with the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19 of the free magnetic layer 17 are being fixed in the direction in which the magnetization direction intersects the magnetization direction of the fixed magnetic layer 15.
[0178] On the other hand, the magnetization direction of center-section (width-of-recording-track field) 17c which does not lap with the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19 of the free magnetic layer 17 and which is a field Anti-in parallel (the direction of illustration X and anti-parallel direction) which it learns from the both-sides sections 17s and 17s, and is different from the truck cross direction 180 degrees

when it is in the condition that an external magnetic field is not given is turned to. If an external magnetic field is given in the direction (the height direction; the direction of illustration Y) perpendicular to the truck cross direction, it will change towards the height direction.
[0179] Electric resistance changes by the relation between fluctuation of the direction of the magnetization by center-section 17c of this free magnetic layer 17, and the fixed magnetization direction of the fixed magnetic layer 15 (this is called magneto-resistive effect), and external magnetic fields, such as a leak field from a record medium, are detected by the electrical-potential-difference change or current change based on this electric resistance value change.
[0180] With the gestalt of this operation, the width method of base 22b of a crevice 22 specifies the width of recording track Tw. In the process shown in drawing 3 , by adjusting the depth dimension of a crevice 22 in adjusting the dimension of the resist layer R1 and the process of drawing 5 can prescribe the width method of base 22b of a crevice 22.
[0181] In addition, the tilt angle to the perpendicular direction to surface 20b of the 2nd antiferromagnetism layer 20 of the side faces 22a and 22a of a crevice 22 is about 20 degrees.
[0182] In all the fields from which it separated from the width-of-recording-track field C, since antiferromagnetism is generated, the 2nd antiferromagnetism layers 20 and 20 have sufficient thickness, and they can certainly fix the magnetization direction of the ferromagnetic layers 19 and 19 and the free magnetic layer 17 in all the fields (both-sides edges S and S of the truck cross direction) from which it separated from the width-of-recording-track field C. That is, the magnetization direction of the free magnetic layer 17 by which the laminating is carried out to the lower layer of the ferromagnetic layers 19 and 19 through the non-magnetic layer 18 is fixed by the RKKY interaction with the ferromagnetic layers 19 and 19 only in the both-sides sections 17s and 17s of the truck cross direction.
[0183] the condition that, as for the field E of the free magnetic layer 17 which laps with base 22b of a crevice 22, an external magnetic field is not impressed -- it is, it learns from the both-sides sections 17s and 17s to which the magnetization direction was fixed, and step is kept with the direction of illustration X, and an anti-parallel direction, and if an external magnetic field is impressed, the magnetization direction will change.
[0184] Therefore, the truck width method Tw of a magnetic sensing element is determined with the base 22 b piece dimension Tw of a crevice 22, and can prevent side leading which moreover reads a record signal in the field from which it separated from the truck width method Tw. As mentioned above, in this invention, it enables a crevice 22 to form base 22b of a crevice 22 by the exact width method using reactive ion etching (RIE) and ion milling which used the electrode layers 21 and 21 as the mask for the 2nd antiferromagnetism layer 20 formed by uniform thickness. That is, since the truck width method Tw of a magnetic sensing element can be specified correctly, the optical width of recording track of a magnetic sensing element becomes equal to the magnetic width of recording track, and an insensible field is not generated, and it corresponds to high recording density-ization, the fall of the playback output at the time of making small the optical width of recording track Tw of a magnetic sensing element can be suppressed.
[0185] Moreover, in the magnetic sensing element shown in drawing 6 , since the free magnetic layer 17 is extended and formed even in the lower layer of the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19, magnetization of the free magnetic layer 17 can make it small to be influenced [which is generated by the surface magnetic charge of the both-sides end face of the free magnetic layer 17] of an anti-field.
[0186] Moreover, since the ferromagnetic layers 19 and 19, the non-magnetic layer 18, and the free magnetic layer 17 have synthetic ferry structure in the lower layer of the 2nd antiferromagnetism layers 20 and 20, the one direction anisotropy field for arranging the magnetization direction in the both-sides sections 17s and 17s of the free magnetic layer 17 in the fixed direction can be enlarged.
[0187] Therefore, it can suppress that the both-sides sections [of the free magnetic layer 17 / 17s and 17s] magnetization direction changes, and the magnetic width of recording track becomes large as a result by the external magnetic field.
[0188] Moreover, even if the switched connection field of the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19 is comparatively weak, it becomes easy to arrange the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the crossing direction certainly. Therefore, magnitude of the magnetic field in the 2nd [said] annealing in a magnetic field can be made into the low magnetic field of 8 (kA/m), and it becomes easy to suppress that the magnetization direction of the fixed magnetic layer 15 changes. In addition, when both the free magnetic layer 17 and the ferromagnetic layer 19 are formed for the magnitude of the 2nd field by NiFe also as 8 (kA/m), for example and a non-magnetic layer 18 is formed by Ru, the one direction anisotropy field of 56 (kA/m) can be generated. Moreover, when both the free magnetic layer 17 and the ferromagnetic layer 19 are formed by CoFe and a non-magnetic layer 18 is formed by Ru, the one direction anisotropy field of 152 (kA/m) can be generated.
[0189] Moreover, with the gestalt of this operation, since a non-magnetic layer 18 is formed by the fixed thickness t1, top-face 18a of a non-magnetic layer 18 becomes a flat side. Therefore, in the process shown in drawing 2 ,

since the laminating of the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 will be carried out on the non-magnetic layer 18 whose front face is a flat side It becomes easy to enlarge the RKKY interaction between the ferromagnetic layer 19 and the free magnetic layer 17 in the synthetic ferry structure where can also form the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 as a layer by which flattening was carried out, and they consist of the ferromagnetic layer 19, a non-magnetic layer 18, and a free magnetic layer 17.
[0190] Moreover, control of the laminating process of the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layers 20 and 20 becomes it easy that top-face 18a of a non-magnetic layer 18 is a flat side. Therefore, in the synthetic ferry structure which thickness of the ferromagnetic layers 19 and 19 can be made thin, and consists of the ferromagnetic layers 19 and 19, a non-magnetic layer 18, and a free magnetic layer 17, the spin FUROPPU field between the ferromagnetic layers 19 and 19 and the free magnetic layer 17 can be enlarged. With the gestalt of this operation, thickness of the ferromagnetic layers 19 and 19 is made to 1.5nm - 4.0nm. Moreover, the one direction anisotropy field concerning the free magnetic layer 17 can be enlarged. For example, when the ferromagnetic layers 19 and 19 and the free magnetic layer 17 are formed by NiFe, said one direction anisotropy field can be set to 56 (kA/m). Or when the ferromagnetic layers 19 and 19 and the free magnetic layer 17 are formed by CoFe, said one direction anisotropy field can be set to 152 (kA/m).
[0191] In addition, at the process of drawing 1 , if a non-magnetic layer 18 is formed with conductive ingredients, such as Ru, a non-magnetic layer 18 can function as a BAKKUDO layer which has the spin filter effectiveness of explaining below, and the field detection sensitivity of a magnetic sensing element can be raised.
[0192] The spin filter effectiveness is explained. Drawing 19 and drawing 20 are the ** type explanatory views for explaining the spin filter effectiveness by the BAKKUDO layer in a spin bulb mold MAG sensing element, drawing 19 is the mimetic diagram showing the example of structure without a BAKKUDO layer, and drawing 20 is the mimetic diagram showing the example of structure with a BAKKUDO layer.
[0193] The huge magnetic-reluctance GMR effectiveness is based mainly on electronic "dispersion depending on spin." That is, the difference of mean free path lambda+ of conduction electron with spin (for example, rise spin) parallel to the magnetization direction of a free magnetic layer and mean free path lambda- of the conduction electron which has reverse parallel spin (for example, down spin) in the magnetization direction is used a magnetic material and here. At drawing 19 and drawing 20 , conduction electron with rise spin is expressed with a upward arrow head, and conduction electron with down spin is expressed with Downarrow. When an electron tends to pass through the free magnetic layer 115, if this electron has rise spin parallel to the magnetization direction of the free magnetic layer 115, it can move freely, but when it has down spin on the contrary, it will be scattered about immediately.
[0194] Mean free path lambda- of the electron in which mean free path lambda+ of an electron with rise spin has down spin to being about 50A is about 6A, and this is because it is extremely as small as about 1/10. The thickness of the free magnetic layer 115 is set up smaller [it is larger than mean free path lambda- of an electron with the down spin which is about 6A, and] than mean free path lambda+ of an electron with the rise spin which is about 50A.
[0195] Therefore, when an electron tends to pass through the free magnetic layer 115, if this electron has rise spin parallel to the magnetization direction of the free magnetic layer 115, it can move freely, but when it has down spin on the contrary, it will be scattered about immediately (filter out is carried out).
[0196] Generating in the fixed magnetic layer 113, the down spin electrons which pass the non-magnetic material layer 114 are scattered about near the interface of the free magnetic layer 115 and the non-magnetic material layer 114, or near the interface of the fixed magnetic layer 113 and the non-magnetic material layer 114, and hardly reach the free magnetic layer 115. That is, even if the magnetization direction of the free magnetic layer 115 rotates this down spin electron, it is changeless to a mean free path, and the resistance rate of change by the GMR effectiveness is not influenced. Therefore, what is necessary is to consider only the behavior of a rise spin electron in the GMR effectiveness.
[0197] The rise spin electron generated in the fixed magnetic layer 113 moves in the inside of the non-magnetic material layer 114 of thickness thinner than mean free path lambda+ of this rise spin electron, the free magnetic layer 115 is reached, and a rise spin electron can pass through the inside of the free magnetic layer 115 freely. This is because the rise spin electron has spin parallel to the magnetization direction of the free magnetic layer 115.
[0198] In the condition that the magnetization direction of the fixed magnetic layer 113 and the magnetization direction of the free magnetic layer 115 serve as anti-parallel, a rise spin electron is no longer an electron with spin parallel to the magnetization direction of the free magnetic layer 115. Then, rise spin electrons will be scattered about near the interface of the free magnetic layer 115 and the non-magnetic material layer 114, and the effective mean free path of a rise spin electron decreases rapidly. That is, resistance increases. Resistance rate of change has the variation of the effective mean free path of a rise spin electron, and a forward correlation.
[0199] As shown in drawing 20 , when the BAKKUDO layer BA is formed, after the rise spin electron which passed the free magnetic layer 115 moves additional mean free path lambda+b determined with the ingredient of

this BAKKUDO layer BA, they are scattered about in the BAKKUDO layer BA. That is, mean free path lambda+ of a rise spin electron is prolonged by additional mean free path lambda+b by having formed the BAKKUDO layer BA.
[0200] With the gestalt of this operation which has the non-magnetic layer 18 which functions as a BAKKUDO layer, the mean free path of the conduction electron of rise spin can be developed. For this reason, the variation of the mean free path of the rise spin electron by impression of an external magnetic field can become large, and can raise more the magnetic-reluctance rate of change (deltaR/R) of a spin bulb mold MAG sensing element.
[0201] The expansion of the mean free path difference of the conduction electron of rise spin and the conduction electron of down spin by the spin filter effectiveness demonstrates effectiveness by the case where the thickness of the free magnetic layer 17 is comparatively thin.
[0202] It cannot become difficult to form so that it may function as the thickness of the free magnetic layer 17 being thinner than 1.5nm as a ferromagnetic ingredient layer, and sufficient magneto-resistive effect cannot be acquired. Moreover, since the conduction electron which carries out the usual dispersion (diffusive scattering), without carrying out specular reflection (specular reflection) also exists, and resistance rate of change falls, it is not desirable.
[0203] Moreover, it is not desirable in order that the rate that the conduction electron of the rise spin scattered about before reaching a non-magnetic layer 18, if the thickness of the free magnetic layer 17 is thicker than 4.5nm increases, and resistance rate of change changes with spin filter effectiveness may decrease.
[0204] Moreover, in drawing 6 , that to which the laminating of said 1st fixed magnetic layer 15a (ferromagnetic ingredient layer) from which the magnetic moment per unit area differs, and said 2nd fixed magnetic layer 15c (ferromagnetic ingredient layer) was carried out through said nonmagnetic interlayer 15b functions as one fixed magnetic layer 15. Namely, the fixed magnetic layer 15 is in the ferrimagnetism condition that the magnetization direction of said ferromagnetic ingredient layer where the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs is carried out through a nonmagnetic interlayer, and they adjoin through said nonmagnetic interlayer serves as anti-parallel.
[0205] By forming 1st fixed magnetic layer 15a in contact with the 1st antiferromagnetism layer 14, and giving 1st annealing in a magnetic field, the exchange anisotropy field by switched connection arises in the interface of 1st fixed magnetic layer 15a and the 1st antiferromagnetism layer 14, and the magnetization direction of 1st fixed magnetic layer 15a is fixed in the direction of illustration Y. When the magnetization direction of 1st fixed magnetic layer 15a is fixed in the direction of illustration Y, the magnetization direction of 2nd fixed magnetic layer 15c which counters through nonmagnetic interlayer 15b is fixed in the magnetization direction of 1st fixed magnetic layer 15a, and the condition of anti-parallel.
[0206] In addition, the direction of the synthetic magnetic moment which added the magnetic moment of 1st fixed magnetic layer 15a and the magnetic moment of 2nd fixed magnetic layer 15c turns into the magnetization direction of the fixed magnetic layer 15.
[0207] Thus, the magnetization direction of 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c is in the ferrimagnetism condition used as anti-parallel, and since 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c fix the magnetization direction of another side mutually, and suit it, and it can stabilize the magnetization direction of the fixed magnetic layer 15 in the fixed direction as a whole, it is desirable.
[0208] As for 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c, it is desirable for it to be formed with a ferromagnetic ingredient, and to be formed with a NiFe alloy, Co, a CoNiFe alloy, a CoFe alloy, a CoNi alloy, etc., for example, to be especially formed of a NiFe alloy, Co, or CoFe. Moreover, as for 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c, being formed with the same ingredient is desirable. In drawing 1 , the magnetic moment per each unit area is changed by forming said 1st fixed magnetic layer 15a and said 2nd fixed magnetic layer 15c using the same ingredient, and changing each thickness further.
[0209] Moreover, nonmagnetic interlayer 15b is formed of a non-magnetic material, and is formed among Ru, Rh, Ir, Os, Cr, Re, and Cu with one sort or these two sorts or more of alloys. Being formed especially of Ru is desirable.

[0210] If the fixed magnetic layer 15 is formed as a thing of nonmagnetic interlayer 15b to which the laminating of 1st fixed magnetic layer 15a and the 2nd fixed magnetic layer 15c was carried out up and down, 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c can fix the mutual magnetization direction, can suit, and can fix the magnetization direction of the fixed magnetic layer 15 in the fixed direction powerfully as a whole. That is, the switched connection field Hex of the 1st antiferromagnetism layer 14 and the fixed magnetic layer 15 can be acquired as a big value with 80 - 160 kA/m.
[0211] Moreover, with the gestalt of this operation, the anti-field (dipole field) by fixed magnetization of the fixed magnetic layer 15 is cancellable, when the static magnetic fields of 1st fixed magnetic layer 15a and 2nd fixed magnetic layer 15c negate each other mutually. Thereby, the contribution to the fluctuation magnetization of the free magnetic layer 17 from the anti-field (dipole field) by fixed magnetization of the fixed magnetic layer 15 can

be decreased.
[0212] Therefore, it becomes easier to amend the direction of fluctuation magnetization of the free magnetic layer 17 towards desired, and it becomes possible to obtain the magnetic sensing element which was excellent in symmetric property with small asymmetry.
[0213] Moreover, although the anti-field (dipole field) Hd by fixed magnetization of the fixed magnetic layer 15 has uneven distribution that it is large and small in the center section, at the edge in the component height direction of the free magnetic layer 17 and single domain-ization in the free magnetic layer 17 may be barred It can prevent that can set the dipole field Hd to Hd=0 mostly, and a magnetic domain wall is made in the free magnetic layer 17 by this, the ununiformity of magnetization occurs, and a Barkhausen noise etc. occurs by making the fixed magnetic layer 15 into the above-mentioned laminated structure.
[0214] However, the fixed magnetic layer 15 may be formed as a ferromagnetic ingredient layer of a monolayer. Moreover, the diffusion prevention layer which consists of Co etc. may be formed between 2nd fixed magnetic layer 15c and the non-magnetic material layer 16. This diffusion prevention layer prevents the counter diffusion of 2nd fixed magnetic layer 15c and the non-magnetic material layer 16.
[0215] Moreover, with the gestalt of this operation, even when the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layers 20 and 20 are formed using the antiferromagnetism ingredient of the same presentation, the exchange anisotropy field of the 2nd antiferromagnetism layers 20 and 20 can be turned in the direction of illustration X, turning the direction of the exchange anisotropy field of the 1st antiferromagnetism layer 14 in the direction of illustration Y. Namely, with the gestalt of this operation, the magnetization direction of the free magnetic layer 17 is fixable in the magnetization direction of the fixed magnetic layer 15, and the direction which intersects perpendicularly.
[0216] In addition, the magnitude of the magnetic moment per unit area of the free magnetic layer 17 and the ferromagnetic layers 19 and 19 needs to differ. The magnitude of the magnetic moment per unit area of the free magnetic layer 17 and the ferromagnetic layers 19 and 19 is expressed with the saturation magnetization (Ms) of a ferromagnetic ingredient layer, and the product of thickness (t). With the gestalt of this operation, thickness of the ferromagnetic layers 19 and 19 is made thinner than the thickness of the free magnetic layer 17. If thickness of the ferromagnetic layers 19 and 19 is made thin, it will become easy for the one direction anisotropy field of the ferromagnetic layers 19 and 19 to become large, and to apply sufficient vertical bias for the free magnetic layer 17.
[0217] Moreover, the magnetic sensing element which has the crevice 30 as shown in drawing 7 can also be obtained after the process shown in drawing 4 by digging the 2nd antiferromagnetism layer 20 deep in the 2nd antiferromagnetism layer 20 by using the electrode layers 21 and 21 as a mask. Base 30b is located in the 2nd antiferromagnetism layer 20, and base 30b of a crevice 30 is the truck width method Tw.
[0218] In the magnetic sensing element shown in drawing 7 , base 30b of a crevice 30 is located in the 2nd antiferromagnetism layer 20, the free magnetic layer 17 and the ferromagnetic layer 19 adjoin through a non-magnetic layer 18, and it will be in the ferrimagnetism condition that the magnetization direction of the free magnetic layer 17 and the magnetization direction of the ferromagnetic layer 19 serve as anti-parallel.
[0219] At this time, the multilayers F which consist of the free magnetic layer 17, a non-magnetic layer 18, and a ferromagnetic layer 19 function as one free magnetic layer and a so-called synthetic ferry free magnetic layer. In a synthetic ferry free magnetic layer, effectiveness equivalent to making thickness of a free magnetic layer thin is acquired, it becomes easy to change magnetization of a free magnetic layer, and the field detection sensitivity of a magneto-resistive effect component improves. In addition, the magnitude of the magnetic moment per unit area of the free magnetic layer 17 and the ferromagnetic layer 19 needs to differ. The magnitude of the magnetic moment per unit area of the free magnetic layer 17 is the sum of the saturation magnetization (Ms) of magnetic layer 17b, the product of thickness (t), and the saturation magnetization (Ms) of diffusion prevention layer 17a and the product of thickness (t), and the magnitude of the magnetic moment per unit area of the ferromagnetic layer 19 is expressed with the saturation magnetization (Ms) of a ferromagnetic layer, and the product of thickness (t).
[0220] In addition, in the field of the 2nd antiferromagnetism layer 20 located in the lower part of base 30b of a crevice 30, when thickness t2 of the field of the 2nd antiferromagnetism layer 20 located in the lower part of base 30b of a crevice 30 is made into 50A or less more greatly than 0A, since a switched connection field does not occur between the ferromagnetic layers 19, it is desirable.
[0221] Moreover, the magnetic sensing element which has the crevice 31 as shown in drawing 8 can also be obtained after the process shown in drawing 4 by digging the 2nd antiferromagnetism layer 20 deep in the ferromagnetic layer 19 by using the electrode layers 21 and 21 as a mask. A crevice 31 has the width method side-face 31a penetrates the 2nd antiferromagnetism layer 20, and base 31b is located in the ferromagnetic layer 19, and base 31b is equivalent to the width of recording track Tw.
[0222] The multilayers F which consist of the free magnetic layer 17, a non-magnetic layer 18, and a ferromagnetic layer 19 also by the magnetic sensing element shown in drawing 8 function as one free magnetic layer and a so-called synthetic ferry free magnetic layer F. In this invention, the 2nd antiferromagnetism layer 20 does not exist in

the upper layer of the sensibility field E where the magnetization direction changes with external magnetization of a free magnetic layer at all. Therefore, fluctuation of the external magnetic field dependency of the magnetization direction of the sensibility field E of the synthetic ferry free magnetic layer F can be made sharp, and the field detection sensitivity of a magnetic sensing element can be improved.

[0223] The manufacture approach of the magnetic sensing element of the gestalt operation of the 4th of this invention is explained. When a magnetic sensing element constitutes a surfacing type head, the laminating of a lower shielding layer and the lower gap layer is carried out through insulator layers, such as 2Oaluminum3 film, on the trailing end face of the slider of ceramic material.

[0224] In the process which was mentioned above and which is shown in drawing 1 like the gestalt of the 1st operation furthermore, on the substrate layer 13 The 1st antiferromagnetism layer 14, 1st fixed magnetic layer 15a, nonmagnetic interlayer 15b, Continuation membrane formation of the multilayers A1 by which the laminating was carried out one by one to the fixed magnetic layer 15 of the synthetic ferry PINDO mold which consists of 2nd fixed magnetic layer 15c, the non-magnetic material layer 16, the free magnetic layer 17, and the non-magnetic layer 18 is carried out in the same vacuum membrane formation equipment according to thin film formation processes, such as a spatter and vacuum deposition.

[0225] Next, in the field of the 1st magnitude which turned to the 1st heat treatment temperature and the direction of Y, 1st annealing in a magnetic field is performed, an exchange anisotropy field is generated between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a, and the magnetization direction of the fixed magnetic layer 15 is fixed in the direction of illustration Y. With the gestalt of this operation, the 1st magnitude of 270 degrees C and a field is set to 800k (A/m) for the 1st heat treatment temperature.

[0226] Next, the multilayers A2 by which carried out continuation membrane formation of the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 by the spatter, and the laminating was carried out from the substrate layer 13 shown in drawing 2 to the 2nd antiferromagnetism layer 20 are obtained.

[0227] In addition, since the ingredient of the substrate layer 13, the 1st antiferromagnetism layer 14, fixed magnetic layer 15of ** 1st a, nonmagnetic middle class 15b, the fixed magnetic layer 15 of the synthetic ferry PINDO mold which consists of 2nd fixed magnetic layer 15c, the non-magnetic material layer 16, the free magnetic layer 17, a non-magnetic layer 18, the ferromagnetic layer 19, and the 2nd antiferromagnetism layer 20 is the same as the gestalt of the 1st operation mentioned above, explanation is omitted.

[0228] Also with the gestalt of this operation, if a non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os, in the 1st annealing in a magnetic field, the front face of a non-magnetic layer 18 will hardly oxidize. Therefore, before carrying out spatter membrane formation of the ferromagnetic layer 19 on a non-magnetic layer 18, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the RKKY interaction which minded the non-magnetic layer 18 between the free magnetic layer 17 and the ferromagnetic layer 19 can be used.

[0229] That is, since it can end even if it does not make the interface of a non-magnetic layer 18 and the ferromagnetic layers 19 and 19 into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the magnetization direction of the free magnetic layer 17 in the fixed direction can be prevented.

[0230] However, since it is magnetically combined by the RKKY interaction through a non-magnetic layer 18, the ferromagnetic layer 19 and the free magnetic layer 17 can obtain sufficient one direction anisotropy field, in order to arrange the magnetization direction of a free magnetic layer in the fixed direction, even when the front face of a non-magnetic layer 18 is processed by milling.

[0231] In addition, the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 can be formed also with the gestalt of this operation using the antiferromagnetism ingredient of the same presentation.

[0232] Next, multilayers A2 are applied to the 2nd annealing in a magnetic field in the field of the 2nd magnitude which turned to the 2nd heat treatment temperature and the direction of X, an exchange anisotropy field is generated between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and the magnetization direction of the ferromagnetic layer 19 is fixed in the direction of illustration X. With the gestalt of this operation, the 2nd magnitude of 250 degrees C and a field is set to 8 (kA/m) for the 2nd heat treatment temperature.

[0233] The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 is produced for the first time in the 2nd annealing process in a magnetic field. Therefore, the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a has been turned in the direction of illustration Y. In order to turn the exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 in the direction of illustration X What is necessary is just to set the 2nd heat treatment temperature as temperature lower than the blocking temperature to which the switched connection field by the 1st antiferromagnetism layer 14 disappears, and to make magnitude of the 2nd field smaller than the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a. Moreover, if 2nd annealing in a magnetic field is performed under these conditions, even if it

forms the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 can be turned in the direction of illustration X, turning the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a in the direction of illustration Y. That is, it becomes easy to fix the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the direction which intersects perpendicularly.
[0234] In addition, the magnitude of the 2nd field at the time of the 2nd annealing in a magnetic field is larger than the anti-field of the saturation field of the free magnetic layer 17 and the ferromagnetic layer 19, the free magnetic layer 17, and the ferromagnetic layer 19, and it is desirable that it is smaller than the spin FUROPPU field in which anti-parallel association between the free magnetic layer 17 and the ferromagnetic layer 19 collapses.
[0235] Next, in the process shown in drawing 9 , the spacing W1 equal to the width of recording track Tw is opened on the 2nd antiferromagnetism layer 20, and the laminating of the 1st resist layer R2 and R2 of a pair is carried out.
[0236] The part across which the 1st resist layer R2 and R2 of the 2nd antiferromagnetism layer 20 faced as shown in drawing 1010 behind the laminating of the 1st resist layer R2 and R2, The part as for which a mask is not carried out by the 1st resist layer R2 and R2 of the 2nd antiferromagnetism layer 20 namely, by ion milling or reactive ion etching (RIE) By deleting to the perpendicular direction (illustration Z direction) to the perpendicular direction to surface 20a, i.e., the truck cross direction, (the direction of illustration X) of the 2nd antiferromagnetism layer 20 The crevice 31 which has the width method side-face 31a penetrates the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and base 31b is located in a non-magnetic layer 18, and base 31b is equivalent to the width of recording track Tw is formed. The side faces 31a and 31a of a crevice 31 are vertical planes to the truck cross direction. In drawing 10 , the crevice 31 is formed so that base 31b of a crevice 31 may be located in a non-magnetic layer 18. The 1st resist layer R2 and R2 is removed after formation of a crevice 31.
[0237] Next, the width method of the truck cross direction forms the resist layer R3 of a wrap 2nd for the field of W2 on the 2nd antiferromagnetism layer 20 around in [opening / of a crevice 31] a crevice 31, and 20. The resist layer R3 is a resist layer for lift off, and notching section R3a and R3a are formed in the lower layer section.
[0238] Furthermore, on the field which is not covered with the resist layer R3 of the 2nd antiferromagnetism layers 20 and 20 as shown in drawing 11 , the electrode layers 26 and 26 which consist of a conductive ingredient are formed by the spatter, and multilayers A3 is formed. After formation of the electrode layers 26 and 26, if the 2nd resist layer R3 is removed, the magnetic sensing element shown in drawing 12 can be obtained.
[0239] In the magnetic sensing element shown in drawing 12 , the side edge edges 26a and 26a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layer 20 and the electrode layers 26 and 26 by which the laminating is carried out on 20 can obtain the heel S1 of multilayers A3, and the magnetic sensing element formed at S1 side rather than the side edge sides 20a and 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layers 20 and 20. In addition, the width-of-recording-track field C is a field which laps with base 31b of the crevice 31 in multilayers A3. That is, the width method of the width-of-recording-track field C is equal to the truck width method Tw. Moreover, the width method of the width-of-recording-track field C is equal to the width method of the sensibility field E which is a field where the magnetization direction of the free magnetic layer 17 changes.
[0240] If the side edge edges 26a and 26a by the side of the width-of-recording-track field C of the electrode layers 26 and 26 are formed in heel [of multilayers A3] S1, and S1 side, they can make more gently-sloping than the side edge sides 20a and 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layers 20 and 20 the level difference which base 31b, the electrode layers 26 and 26, and the 2nd antiferromagnetism layers 20 and 20 of a crevice 31 build. Therefore, even if it makes small thickness of the up gap layer 23 of the upper layer of a magnetic sensing element, the up gap layer 23 can be certainly formed on this level difference. Namely, the electric short circuit between the up shielding layer 24, the electrode layers 26 and 26, the 2nd antiferromagnetism layers 20 and 20, the ferromagnetic layers 19 and 19, and a non-magnetic layer 18 can be prevented more certainly, and it can respond now to narrow gap-ization.
[0241] Moreover, if the distance between the up shielding layer [/ near the both sides of the width-of-recording-track field C of multilayers A3] 24 and the lower shielding layer 11 becomes large, it will pass along between the up shielding layer 24 and the lower shielding layers 11, the field from the record medium generated from the recording track of the both sides of the recording track for detection will become easy to invade into a magnetic sensing element, and the effective width of recording track will become large. That is, it becomes easy to generate the cross talk between recording tracks.
[0242] In this invention, since the level difference which a crevice 31, the electrode layers 26 and 26, and the 2nd antiferromagnetism layers 20 and 20 build as mentioned above can be made gently-sloping, it can suppress that the distance between the up shielding layer [/ near the both sides of the width-of-recording-track field C] 24 and the lower shielding layer 11 becomes large, and the effective width of recording track can be made small.

[0243] Specifically The inside of the ferromagnetic layers 19 and 19, the 2nd antiferromagnetism layers 20 and 20, and the electrode layers 26 and 26, The distance between the up shielding layer 24 in the fields S2 and S2 which lap only with the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layers 20 and 20, and the lower shielding layer 11 Gls, When distance between the up shielding layer 24 in the location which laps with the center C1 of multilayers A3, and the lower shielding layer 11 is set to Glc, it is desirable to set the value of said difference of Gls and Glc as the range which fills Glc<=Gls<=Glc+90nm. It is setting said Gls and said value of Glc as the range which fills Glc<=Gls<=Glc+70nm more preferably. It is setting said Gls and said value of Glc as the range which fills Glc<=Gls<=Glc+30nm still more preferably.
[0244] Or it is desirable to set said Gls and said value of Glc as the range which fills 1.00 <=Gls/Glc<=2.50. It is setting said Gls and said value of Glc as the range which fills 1.00 <=Gls/Glc<=2.17 more preferably. It is setting said Gls and said value of Glc as the range which fills 1.00 <=Gls/Glc<=1.50 still more preferably.
[0245] The manufacture approach of the magnetic sensing element of the gestalt operation of the 5th of this invention is explained. When a magnetic sensing element constitutes a surfacing type head, the laminating of a lower shielding layer and the lower gap layer is carried out through insulator layers, such as 2Oaluminum3 film, on the trailing end face of the slider of ceramic material.
[0246] Furthermore, it sets at the process which was mentioned above and which is shown in drawing 1 as well as the gestalt of the 1st operation. The substrate layer 13, the 1st antiferromagnetism layer 14, 1st fixed magnetic layer 15a, nonmagnetic interlayer 15b, Continuation membrane formation of the multilayers A1 by which the laminating was carried out one by one to the fixed magnetic layer 15 of the synthetic ferry PINDO mold which consists of 2nd fixed magnetic layer 15c, the non-magnetic material layer 16, the free magnetic layer 17, and the non-magnetic layer 18 is carried out in the same vacuum membrane formation equipment according to thin film formation processes, such as a spatter and vacuum deposition.
[0247] Next, in the field of the 1st magnitude which turned to the 1st heat treatment temperature and the direction of Y, 1st annealing in a magnetic field is performed, an exchange anisotropy field is generated between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a, and the magnetization direction of the fixed magnetic layer 15 is fixed in the direction of illustration Y. With the gestalt of this operation, the 1st magnitude of 270 degrees C and a field is set to 800k (A/m) for the 1st heat treatment temperature.
[0248] Next, the multilayers A2 by which carried out continuation membrane formation of the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 by the spatter, and the laminating was carried out from the substrate layer 13 shown in drawing 2 to the 2nd antiferromagnetism layer 20 are obtained.
[0249] In addition, since the ingredient of the substrate layer 13, the 1st antiferromagnetism layer 14, 1st fixed magnetic layer 15a, nonmagnetic middle class 15b, the fixed magnetic layer 15 of the synthetic ferry PINDO mold which consists of 2nd fixed magnetic layer 15c, the non-magnetic material layer 16, the free magnetic layer 17, a non-magnetic layer 18, the ferromagnetic layer 19, and the 2nd antiferromagnetism layer 20 is the same as the gestalt of the 1st operation mentioned above, explanation is omitted.
[0250] Also with the gestalt of this operation, if a non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os, in the 1st annealing in a magnetic field, the front face of a non-magnetic layer 18 will hardly oxidize. Therefore, before carrying out spatter membrane formation of the ferromagnetic layer 19 on a non-magnetic layer 18, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the RKKY interaction which minded the non-magnetic layer 18 between the free magnetic layer 17 and the ferromagnetic layer 19 can be used.
[0251] That is, since it can end even if it does not make the interface of a non-magnetic layer 18 and the ferromagnetic layer 19 into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the magnetization direction of the free magnetic layer 17 in the fixed direction can be prevented.
[0252] However, since it is magnetically combined by the RKKY interaction through a non-magnetic layer 18, the ferromagnetic layer 19 and the free magnetic layer 17 can obtain sufficient one direction anisotropy field, in order to arrange the magnetization direction of the free magnetic layer 17 in the fixed direction, even when the front face of a non-magnetic layer 18 is processed by milling.
[0253] In addition, the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 can be formed also with the gestalt of this operation using the antiferromagnetism ingredient of the same presentation.
[0254] Next, multilayers A2 are applied to the 2nd annealing in a magnetic field in the field of the 2nd magnitude which turned to the 2nd heat treatment temperature and the direction of X, an exchange anisotropy field is generated between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and the magnetization direction of the ferromagnetic layer 19 is fixed in the direction of illustration X. With the gestalt of this operation, the 2nd magnitude of 250 degrees C and a field is set to 8 (kA/m) for the 2nd heat treatment temperature.
[0255] The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 is produced for the first time in the 2nd annealing process in a magnetic field. Therefore, the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a has been

turned in the direction of illustration Y. In order to turn the exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 in the direction of illustration X What is necessary is just to set the 2nd heat treatment temperature as temperature lower than the blocking temperature to which the switched connection field by the 1st antiferromagnetism layer 14 disappears, and to make magnitude of the 2nd field smaller than the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a. Moreover, if 2nd annealing in a magnetic field is performed under these conditions, even if it forms the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation The exchange anisotropy field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 can be turned in the direction of illustration X, turning the direction of the exchange anisotropy field between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a in the direction of illustration Y. That is, it becomes easy to fix the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the direction which intersects perpendicularly.
[0256] In addition, the magnitude of the 2nd field at the time of the 2nd annealing in a magnetic field is larger than the anti-field of the saturation field of the free magnetic layer 17 and the ferromagnetic layer 19, the free magnetic layer 17, and the ferromagnetic layer 19, and it is desirable that it is smaller than the spin FUROPPU field in which anti-parallel association between the free magnetic layer 17 and the ferromagnetic layer 19 collapses.
[0257] Next, in the process shown in drawing 9 , the spacing W1 equal to the width of recording track Tw is opened on the 2nd antiferromagnetism layer 20, and the laminating of the 1st resist layer R2 and R2 of a pair is carried out.
[0258] The part across which the 1st resist layer R2 and R2 of the 2nd antiferromagnetism layer 20 faced as shown in drawing 1010 behind the laminating of the 1st resist layer R2 and R2, The part as for which a mask is not carried out by the 1st resist layer R2 and R2 of the 2nd antiferromagnetism layer 20 namely, by ion milling or reactive ion etching (RIE) A crevice 31 is formed by deleting to the perpendicular direction (illustration Z direction) to the perpendicular direction to surface (side edge side) 20a, i.e., the truck cross direction, (the direction of illustration X) of the 2nd antiferromagnetism layer 20. The side faces 31a and 31a of a crevice 31 are vertical planes to the truck cross direction. In drawing 10 , the crevice 31 is formed so that base 31b of a crevice 31 may be located in a non-magnetic layer 18. The 1st resist layer R2 and R2 is removed after formation of a crevice 31.
[0259] Next, as shown in drawing 13 , width method W3 of the truck cross direction of base R4a forms the 2nd resist layer R4 smaller than the width method W1 of base R1b of the resist layer R1 for lift off on base 31b of a crevice 31.
[0260] Next, as shown in drawing 14 , multilayers A4 is formed by forming the electrode layers 27 and 27 by the spatter on the 2nd antiferromagnetism layer 20 and 20 [the field which is not covered with the 2nd resist layer R4 of base 31b of a crevice 31, and].
[0261] In addition, by adjusting whenever [incident angle / of a spatter], and extending and forming the side edge edges 27a and 27a by the side of the width-of-recording-track field C of the electrode layers 27 and 27 till the place which the 2nd resist layer R4 has joined to base 31b of a crevice 31 The side edge edges 27a and 27a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layer 20 and the electrode layers 27 and 27 by which a laminating is carried out on 20 Rather than the side edge edges 19a and 19a by the side of the width-of-recording-track field C of the ferromagnetic layers 19 and 19 (side edge side), and the side edge edges 20a and 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layers 20 and 20 (side edge side), it extends and can be formed in the center-section C1 side of multilayers A4. In addition, in drawing 14 , the width-of-recording-track field C is a field inserted into the side edge edges 27a and 27a of the electrode layers 27 and 27.
[0262] At this time, side edge marginal 27a of truck cross direction dimension W3 of base R4a of the resist layer R4 and the electrode layers 27 and 27 and the distance between 27a become equal. In addition, side edge marginal 27a of the electrode layers 27 and 27 and the distance between 27a specify the truck width method Tw of a magnetic sensing element. It is the field E of this truck width method Tw, i.e., the sensibility field whose width-of-recording-track field C is a field which can demonstrate a magneto-resistive effect substantially.
[0263] After membrane formation of the electrode layers 27 and 27, removal of the 2nd resist layer R4 obtains multilayers A4, as shown in drawing 15 .
[0264] In addition, the magnetic sensing element of the gestalt of this operation can form the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation.
[0265] In addition, the protective layer which consists of non-magnetic materials, such as Ta, between the 2nd antiferromagnetism layer 20 and the electrode layers 27 and 27 may be formed.
[0266] The magnetic sensing element which carries out the laminating of the up gap layer 23 and the up shielding layer 24 on multilayers A4, and is shown in drawing 15 is obtained.
[0267] The ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layers 20 and 20 are formed with an ingredient with large specific resistance compared with the electrode layers 27 and 27. If the laminating of the

electrode layers 27 and 27 is carried out only on the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layer 20, and 20, the direct current supplied to the electrode layers 27 and 27 will flow through the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layers 20 and 20 to a non-magnetic layer 18, the free magnetic layer 17, a non-magnetic material layer, and the fixed magnetic layer 15, and the direct-current-resistance value of a magnetic sensing element will become large.
[0268] The side edge edges 27a and 27a by the side of the width-of-recording-track field C of the electrode layers 27 and 27 If it extends at the center-section C1 side of multilayers A4 rather than the side edge edges 19a and 19a by the side of the width-of-recording-track field C of the ferromagnetic layers 19 and 19 (side edge side), and the side edge edges 20a and 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layers 20 and 20 (side edge side) The side edge edges 27a and 27a of the electrode layers 27 and 27 are extensible even on a non-magnetic layer 18, and since the direct current supplied to the electrode layers 27 and 27 can be passed without minding the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layers 20 and 20, the direct-current-resistance value of a magnetic sensing element can be made small.
[0269] In addition, the width of recording track Tw of the magnetic sensing element of drawing 15 Since it is prescribed by side edge marginal 27a by the side of the width-of-recording-track field C of the electrode layers 27 and 27 of a pair, and the distance between 27a When a presentation changes in the field side edge marginal (side edge side) 20a by the side of the width-of-recording-track field C of the 2nd antiferromagnetism layer 20 and 20, and near 20a or who arises Even if it becomes easy to move the both-sides sections [of the free magnetic layer 17 which laps side edge marginal (side edge side) 20a of the 2nd antiferromagnetism layer 20 and 20, and near 20a / 17s and 17s] magnetization direction, it can suppress that the width of recording track Tw changes.
[0270] In addition, although the crevice 31 is formed at the process of drawing 10 mentioned above so that base 31b may be located in a non-magnetic layer 18, a crevice where a base is located in the 2nd antiferromagnetism layer 20 or the ferromagnetic layer 19 may be formed in this invention.
[0271] Moreover, in the process shown in drawing 1 , when forming multilayers A1, the ingredient 50 with specific resistance lower than a non-magnetic layer 18, for example, the conductive ingredient layer which consists of Cu, is formed between a non-magnetic layer 18 and the free magnetic layer 17, and the magnetic sensing element finally shown in drawing 16 may be made to be obtained.
[0272] If the conductive ingredient layer 50 which specific resistance becomes from a conductive ingredient lower than a non-magnetic layer 18 is formed, since it can do now the bigger spin filter effectiveness than the case of only a non-magnetic layer 18 so and the field detection sensitivity of a magnetic sensing element can be raised further, it is desirable. In addition, if the conductive ingredient layer 50 is formed using Cu, the value of the free magnetic layer 17 formed of NiFe or CoFeNi and a crystal-lattice constant becomes near, and can do the big spin filter effectiveness so.
[0273] When forming the conductive ingredient layer 50, a non-magnetic layer 18 can be formed by Ru as that whose thickness t3 is 0.4-1.1nm, and the conductive ingredient layer 50 can be further formed by Cu as that whose thickness t4 is 0.3-0.5nm.
[0274] Moreover, in the process shown in drawing 1 , when forming multilayers A1 Carried out the laminating of 1st free magnetic layer 40a (ferromagnetic ingredient layer) and 2nd free magnetic layer 40c (ferromagnetic ingredient layer) from which the magnitude of the magnetic moment per unit area differs the free magnetic layer 40 through nonmagnetic interlayer 40b. It forms as the so-called synthetic ferry free type of a free magnetic layer, and you may make it obtain the magnetic sensing element finally shown in drawing 17 .
[0275] The free magnetic layer of the magnetic sensing element shown in drawing 17 is in the ferrimagnetism condition that the magnetization direction of a ferromagnetic ingredient layer where the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs is carried out through a non-magnetic layer, and they adjoin through a non-magnetic layer serves as anti-parallel.
[0276] 1st free magnetic layer 40a consists of a diffusion prevention layer (interlayer) 40a1 and a magnetic layer 40a2. This diffusion prevention layer 40a1 consists of Co or CoFe, and prevents the counter diffusion of a magnetic layer 40a2 and the non-magnetic material layer 16.
[0277] the -- the [1 free magnetic layer 40a and] -- as for 2 free magnetic layer 40c, it is desirable for it to be formed with a ferromagnetic ingredient, and to be formed with a NiFe alloy, Co, a CoNiFe alloy, a CoFe alloy, a CoNi alloy, etc., for example, to be formed especially with a NiFe alloy.
[0278] Moreover, nonmagnetic interlayer 40b is formed of a non-magnetic material, and is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Os, Cr, Re, and Cu. Being formed especially of Ru is desirable.
[0279] In addition, 1st free magnetic layer 40a and 2nd free magnetic layer 40c are formed so that the magnetic moments per each unit area may differ. The magnetic moment per unit area is expressed with the product of saturation magnetization (Ms) and thickness (t).
[0280] With the gestalt of this operation, since the diffusion prevention layer 40a1 is formed between 1st free magnetic layer 40a and the non-magnetic material layer 16, the sum of the magnetic moment per unit area of a

magnetic layer 40a2 and the magnetic moment per unit area of the diffusion prevention layer 40a1 and the magnetic moment per unit area of 2nd free magnetic layer 40c are changed.

[0281] In addition, as for the thickness of 2nd free magnetic layer 40c, it is desirable that it is the range of 0.5-2.5nm. Moreover, as for the thickness of 1st free magnetic layer 40a, it is desirable that it is the range of 2.5-4.5nm. In addition, it is the range of 3.5-4.0nm that it is the range whose thickness of 1st free magnetic layer 40a is 3.0-4.0nm more desirable still more preferably. Since it becomes impossible to enlarge the magnetic-reluctance rate of change of a spin bulb mold MAG sensing element when it separates from the range of the above [the thickness of 1st free magnetic layer 40a], it is not desirable.

[0282] the [from which the magnetic moment per unit area differs in drawing 4] -- the [1 free magnetic layer 40a and] -- that to which the laminating of the 2 free magnetic layer 40c was carried out through nonmagnetic interlayer 40b functions as one free magnetic layer 40.

[0283] the -- the [1 free magnetic layer 40a and] -- the magnetization direction of 2 free magnetic layer 40c is in a ferrimagnetism condition of anti-parallel different 180 degrees. this time -- the -- the direction of the field which the magnetization direction of 1 free magnetic layer 40a generates from the ferromagnetic layer 19 -- suitable -- the -- an opposite direction will be turned to the magnetization direction of 2 free magnetic layer 40c 180 degrees

[0284] the -- the [1 free magnetic layer 40a and] -- if the magnetization direction of 2 free magnetic layer 40c will be in a ferrimagnetism condition of anti-parallel different 180 degrees, effectiveness equivalent to making thickness of the free magnetic layer 40 thin will be acquired, effectual magnetic thickness (Msxt) will become small, it will become easy to change magnetization of the free magnetic layer 40, and the field detection sensitivity of a magneto-resistive effect component will improve.

[0285] the -- the [the magnetic moment per unit area of 1 free magnetic layer 40a, and] -- the direction of the synthetic magnetic moment per [which added the magnetic moment per unit area of 2 free magnetic layer 40c] unit area turns into the magnetization direction of the free magnetic layer 40.

[0286] However, it is only the magnetization direction of 1st free magnetic layer 40a which is contributed to an output by relation with the magnetization direction of the fixed magnetic layer 15.

[0287] Moreover, if the relation of the magnetic thickness of 1st free magnetic layer 40a and 2nd free magnetic layer 40c is ** and it is carried out, the spin FUROPPU field of the free magnetic layer 40 can be enlarged.

[0288] A spin FUROPPU field points out the magnitude of the external magnetic field whose magnetization direction of two magnetic layers stops being anti-parallel, when an external magnetic field is impressed to two magnetic layers whose magnetization directions are anti-parallel.

[0289] Drawing 18 is shown as a conceptual diagram of the hysteresis loop of the free magnetic layer 40. This M-H curve shows change of the magnetization M of the free magnetic layer 40 when impressing an external magnetic field from the truck cross direction to the free magnetic layer 40 of a configuration of being shown in drawing 17 .

[0290] Moreover, the arrow head shown by F1 expresses the magnetization direction of 1st free magnetic layer 40a among drawing 18 , and the arrow head shown by F2 expresses the magnetization direction of 2nd free magnetic layer 40c.

[0291] it is shown in drawing 18 -- as -- time an external magnetic field is small -- the -- the [1 free magnetic layer 40a and] -- although the ferrimagnetism condition of arrow heads F1 and F2, i.e., the direction, is anti-parallel, if 2 free magnetic layer 40c exceeds a value with the magnitude of an external magnetic field H -- the -- the [1 free magnetic layer 40a and] -- RKKY association of 2 free magnetic layer 40c is destroyed, and it becomes impossible to maintain a ferrimagnetism condition This is spin FUROPPU transition. Moreover, the magnitude of an external magnetic field in case this spin FUROPPU transition occurs is a spin FUROPPU field, and Hsf shows in drawing 18 . In addition, the coercive force of magnetization of the free magnetic layer 40 is shown by the inside Hcf of drawing.

[0292] the -- the [1 free magnetic layer 40a and] -- if it is formed so that the magnetic moments per each unit area of 2 free magnetic layer 40c may differ, the spin FUROPPU field Hsf of the free magnetic layer 40 will become large. The range of a field where the free magnetic layer 40 maintains a ferrimagnetism condition becomes large by this, and the stability of the ferrimagnetism condition of the free magnetic layer 40 increases.

[0293] Moreover, when the diffusion prevention layer 40a1 is formed like the gestalt of this operation, as for the magnetic layer 40a2 of the 1st free magnetic layer and 2nd free magnetic layer 40c which constitute a free magnetic layer, it is desirable to form with the magnetic material which has the following presentations. It is said CoFeNi alloy and the presentation ratio of Fe is [the presentation ratio of nickel of the remaining presentation ratios] Co below 15 atom % below 15 atom % above pentatomic % above 7 atom %.

[0294] The switched connection field in the RKKY interaction which this generates between 1st free magnetic layer 40a and 2nd free magnetic layer 40c can be strengthened. Specifically, it can enlarge even about 293 (kA/m), a field (Hsf), i.e., a spin FUROPPU field, in case an anti-parallel condition collapses.

[0295] Therefore, pinning of the magnetization of the both-sides edge of 1st free magnetic layer 40a located under the ferromagnetic layer 19 and 2nd free magnetic layer 40c is appropriately changed into an anti-parallel condition,

and generating of side leading can be controlled.
[0296] In addition, it is desirable to form the both sides of 1st free magnetic layer 40a and 2nd free magnetic layer 40c with said CoFeNi alloy. By this, it can be stabilized more, a high spin FUROPPU field can be acquired, and 1st free magnetic layer 40a and 2nd free magnetic layer 40c can be appropriately magnetized in the anti-parallel condition.
[0297] moreover -- it is above-mentioned presentation within the limits -- the -- the [1 free magnetic layer 40a and] -- the magnetostriction of 2 free magnetic layer 40c can be stored within the limits of -3x10-6 to 3x10-6, and coercive force can be made small below 790 (A/m).
[0298] Furthermore, it is possible to aim at appropriately control of reduction of the resistance variation (deltaR) by improvement in the soft magnetic characteristics of the free magnetic layer 40 and diffusion of nickel between the non-magnetic material layers 16 or resistance rate of change (deltaR/R).
[0299] in addition, when 1st free magnetic layer 40a consists only of a magnetic layer 40a2 and the diffusion prevention layer 40a1 is not formed An empirical formula is shown by CoFeNi, the presentation ratio of Fe is below 17 atom % above 9 atom %, the presentation ratio of nickel is below 10 atom % above 0.5 atom %, and, as for the remaining presentation, it is desirable to form a magnetic layer 40a2 and 2nd free magnetic layer 40c using the magnetic material which is Co.
[0300] In addition, in all the magnetic sensing elements mentioned above, the conductive ingredient layer 50 which consists of an ingredient with specific resistance lower than a non-magnetic layer 18 between a non-magnetic layer 18 and the free magnetic layer 17 may be formed. Moreover, the free magnetic layer 17 of all the magnetic sensing elements mentioned above may be formed as a free magnetic layer of a synthetic ferry free mold.
[0301] It is able to make the side faces 31a and 31a of a crevice 31, and the side faces 22a and 22a of a crevice 22 to become a vertical plane to the truck cross direction also by the magnetic sensing element shown in drawing 12 , drawing 15 , drawing 16 , and drawing 17 . That is, since the 2nd antiferromagnetism layers 20 and 20 generate antiferromagnetism in all the fields from which it separated from the width-of-recording-track field C, it can have sufficient thickness, and in all the fields from which it separated from the width-of-recording-track field C, the magnetization direction of the free magnetic layer 17 can certainly be fixed.
[0302] Therefore, the magnetization direction of the free magnetic layer 17 can be moved in the width-of-recording-track field C of a magnetic sensing element (sensibility field E), and side leading in the width-of-recording-track field C circumference can be prevented.
[0303] Moreover, since the free magnetic layer 17 is extended and formed even in the lower layer of the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19, magnetization of the free magnetic layer 17 can make it small to be influenced [which is generated by the surface magnetic charge of the both-sides end face of the free magnetic layer 17] of an anti-field.
[0304] Moreover, since the ferromagnetic layers 19 and 19, the non-magnetic layer 18, and the free magnetic layer 17 have synthetic ferry structure in the lower layer of the 2nd antiferromagnetism layers 20 and 20, the one direction anisotropy field for arranging the magnetization direction in the both-sides sections 17s and 17s of the free magnetic layer 17 in the fixed direction can be enlarged.
[0305] Therefore, it can suppress that the both-sides sections [of the free magnetic layer 17 / 17s and 17s] magnetization direction changes, and the magnetic width of recording track becomes large as a result by the external magnetic field.
[0306] Moreover, even if the switched connection field of the 2nd antiferromagnetism layers 20 and 20 and the ferromagnetic layers 19 and 19 is comparatively weak, it becomes easy to arrange the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the crossing direction certainly. Therefore, magnitude of the magnetic field in the 2nd [said] annealing in a magnetic field can be made into the low magnetic field of 8000 A/m, and it becomes easy to suppress that the magnetization direction of the fixed magnetic layer 15 changes.
[0307] Moreover, with the gestalt of this operation, in the process shown in drawing 2 , since the laminating of the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 is carried out on the non-magnetic layer 18 whose front face is a flat side It becomes easy to enlarge the RKKY interaction between the ferromagnetic layer 19 and the free magnetic layer 17 in the synthetic ferry structure where can also form the ferromagnetic layer 19 and the 2nd antiferromagnetism layer 20 as a layer by which flattening was carried out, and they consist of the ferromagnetic layer 19, a non-magnetic layer 18, and a free magnetic layer 17.
[0308] Moreover, control of the laminating process of the ferromagnetic layers 19 and 19 and the 2nd antiferromagnetism layer 20 and 20 becomes it easy that top-face 18a of a non-magnetic layer 18 is a flat side. Therefore, in the synthetic ferry structure which thickness of the ferromagnetic layers 19 and 19 can be made thin, and consists of the ferromagnetic layers 19 and 19, a non-magnetic layer 18, and a free magnetic layer 17, the spin FUROPPU field between the ferromagnetic layers 19 and 19 and the free magnetic layer 17 can be enlarged. With the gestalt of this operation, thickness of the ferromagnetic layers 19 and 19 is made to 1.5nm - 4.0nm. Moreover,

the one direction anisotropy field concerning the free magnetic layer 17 can be enlarged. For example, when the ferromagnetic layers 19 and 19 and the free magnetic layer 17 are formed by NiFe, said one direction anisotropy field can be set to 56 (kA/m). Or when the ferromagnetic layers 19 and 19 and the free magnetic layer 17 are formed by CoFe, said one direction anisotropy field can be set to 152 (kA/m).

[0309] In addition, if a non-magnetic layer 18 is formed with conductive ingredients, such as Ru, a non-magnetic layer 18 will have the spin filter effectiveness, and can raise the field detection sensitivity of a magnetic sensing element.

[0310] By the way, in drawing 1 thru/or drawing 17 , the electrode layers 21, 26, and 27 are formed on the both-sides sections S and S of the truck cross direction (the direction of illustration X) of the multilayers which have a fixed magnetic layer, a non-magnetic material layer, and a free magnetic layer. The manufacture approach of the magnetic sensing element of a CIP (current in the plane) mold that the current which flows in said multilayers flowed the inside of said multilayers from said electrode layers 21, 26, and 27 in the parallel direction to the film surface of each class was explained.

[0311] On the other hand, the manufacture approach of the magnetic sensing element explained henceforth [drawing 21] is the manufacture approach of the magnetic sensing element of a CPP (current perpendicular to theplane) mold that the current of said multilayers which an electrode layer is prepared up and down and flows in said multilayers from said electrode layer flows perpendicularly to the film surface of each class of said multilayers.

[0312] First, in drawing 21 , the same multilayers A1 as having formed the lower electrode layer 70 which consists of magnetic materials, such as NiFe, on a substrate (not shown), and serves as a lower shielding layer, and having formed by drawing 1 on it are formed.

[0313] Then, in the field of the 1st magnitude which turned to the 1st heat treatment temperature and the direction of Y for multilayers A1, 1st annealing in a magnetic field is performed, an exchange anisotropy field is generated between the 1st antiferromagnetism layer 14 and 1st fixed magnetic layer 15a, and the magnetization direction of the fixed magnetic layer 15 is fixed in the direction of illustration Y. With the gestalt of this operation, the 1st magnitude of 270 degrees C and a field is set to 800k (A/m) for said 1st heat treatment temperature.

[0314] When explaining drawing 1 , as stated, a non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os. In addition, when forming a non-magnetic layer 18 by Ru, since the RKKY interaction between the ferromagnetic layer 19 and the free magnetic layer 17 can be enlarged if 0.8-1.1nm of thickness t1 of a non-magnetic layer is formed as a thing so that it may be more preferably set to 0.85-0.9nm, it is desirable.

[0315] Next, as shown in drawing 22 , on a non-magnetic layer 18, the ferromagnetic layer 19 is re-formed and continuation membrane formation of the 2nd antiferromagnetism layer 20 and the insulating layer 71 is carried out further at the ferromagnetic layer 19 top.

[0316] An insulating layer 71 is formed by insulating materials, such as aluminum 2O3, SiO2, AlN and Ti 2O3, Ti3O5, and aluminum-Si-O.

[0317] Next, the multilayers B1 formed to the insulating layer 71 are applied to the 2nd annealing in a magnetic field in the field of the 2nd magnitude which turned to the 2nd heat treatment temperature and the direction of X, an exchange anisotropy field is generated between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19, and the magnetization direction of the ferromagnetic layer 19 is fixed to an anti-parallel direction different 180 degrees from the direction of illustration X. When the magnetization direction of the ferromagnetic layer 19 is fixed to an anti-parallel direction different 180 degrees from the direction of illustration X, the magnetization direction of the free magnetic layer 17 is fixed in the direction of illustration X by the RKKY interaction with the ferromagnetic layer 19 through a non-magnetic layer 18. With the gestalt of this operation, the 2nd magnitude of 250 degrees C and a field is set to 24k (A/m) for said 2nd heat treatment temperature.

[0318] That the magnetization direction of the free magnetic layer 17 and the ferromagnetic layer 19 becomes the above relation has the magnetic moment larger than the magnetic moment per unit area of the ferromagnetic layer 19 per unit area of the free magnetic layer 17, and it is because the 2nd magnitude of a field is smaller than the spin FUROPPU field between the free magnetic layer 17 and the ferromagnetic layer 19.

[0319] The exchange anisotropy field by the 2nd antiferromagnetism layer 20 is produced for the first time in the 2nd annealing process in a magnetic field. Therefore, the direction of the exchange anisotropy field by the 1st antiferromagnetism layer 14 has been turned in the direction of illustration Y. In order to turn the exchange anisotropy field by the 2nd antiferromagnetism layer 20 to anti-in parallel it differs from the direction of illustration X 180 degrees What is necessary is just to set said 2nd heat treatment temperature as temperature lower than the blocking temperature to which the switched connection field by the 1st antiferromagnetism layer 14 disappears, and to make magnitude of said 2nd field smaller than the exchange anisotropy field by the 1st antiferromagnetism layer 14. Moreover, if 2nd annealing in a magnetic field is performed under these conditions, even if it forms the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of

the same presentation The exchange anisotropy field by the 2nd antiferromagnetism layer 20 can be turned to the direction of illustration X, and an anti-parallel direction, turning the direction of the exchange anisotropy field by the 1st antiferromagnetism layer 14 in the direction of illustration Y. That is, it becomes easy to fix the magnetization direction of the free magnetic layer 17 in the magnetization direction of the fixed magnetic layer 15 and the direction which intersects perpendicularly.
[0320] In addition, the magnitude of the 2nd field at the time of the 2nd annealing in a magnetic field is larger than the anti-field of the saturation field of the free magnetic layer 17 and the ferromagnetic layer 19, the free magnetic layer 17, and the ferromagnetic layer 19, and it is desirable that it is smaller than the spin FUROPPU field in which anti-parallel association between the free magnetic layer 17 and the ferromagnetic layer 19 collapses.
[0321] Next, the resist layer 90 in which hole 90a was prepared by exposure development in the center section of the truck cross direction (the direction of illustration X) on the insulating layer 71 is formed. Inside end-face 90b of the resist layer 90 is a vertical plane over the front face (or substrate front face) of an insulating layer 71. However, inside end-face 90b may be formed in respect of the inclined plane where it applies to a top face from an inferior surface of tongue, and spacing to the truck cross direction of hole 90a spreads gradually, or a curve.
[0322] Next, by the ion milling or reactive ion etching (RIE) from [which is shown in drawing 24] arrow-head F, the insulating layer 71 which is not covered with the resist layer 90, the 2nd antiferromagnetism layer 20, and the ferromagnetic layer 19 are deleted completely, and a non-magnetic layer 18 is deleted to the middle. In drawing 24 , side-face 31a of the crevice 31 formed in multilayers is a vertical plane over the front face (or substrate front face) of an insulating layer 71. And the resist layer 90 is removed.
[0323] In addition, when inside end-face 90b of the resist layer 90 is an inclined plane or a curve side, or when the ion beam incident angle in ion milling leans from the perpendicular direction, side-face 31a of the crevice 31 formed in multilayers of the delete lump by said ion milling is also formed as an inclined plane or a curve side.
[0324] With the gestalt of this operation, after forming the resist layer 90 on the insulating layer 71 formed in the state of the solid film, ion milling or reactive ion etching (RIE) is performed by using the resist layer 90 as a mask. However, instead of forming the insulating layer 71 formed at drawing 2222 process in the state of the solid film After forming the resist layer for lift off in the center section of the truck cross direction on the protective layer which consists of Ta formed on the 2nd antiferromagnetism layer 20 or the 2nd antiferromagnetism layer 20 (the direction of illustration X) Spatter membrane formation of the same insulating ingredient as an insulating layer 71 may be carried out, and the insulating layer which removes the account resist of back to front and by which the hole was prepared in the center section of the truck cross direction (the direction of illustration X) may be formed. In this case, by using as a mask the insulating layer in which said this hole was prepared, by ion milling or reactive ion etching (RIE), the 2nd antiferromagnetism layer and the ferromagnetic layer 19 are deleted, and a crevice is formed.
[0325] In addition, it is more desirable to perform it, after the 2nd [said] annealing in a magnetic field forms a crevice 31 in multilayers B1.
[0326] At the process shown in drawing 25 , spatter membrane formation of other insulating layers 72 which are missing from side-face 31a and base 31b of said crevice 31 from on an insulating layer 71, and consist of insulating materials, such as aluminum 2O3, SiO2 and AlN, or TiC, is carried out. The ion beam spatter method, the long slow spatter method, the collimation spatter method, etc. can be used for a spatter.
[0327] The point which it should be careful of here is in the spatter include angle theta 1 at the time of forming other insulating layers 72. it is desirable that it enlarges said spatter include angle theta 1 as much as possible by this invention although the direction G of a spatter has the spatter include angle of theta 1 to the perpendicular direction of the film surface of each class of multilayers as shown in drawing 25 (namely, -- more -- to put it to sleep), and other insulating layers 72 tend to be formed by side-face 31a of a crevice 31. For example, said spatter include angle theta 1 is 50 degrees to 70 degrees.
[0328] Thus, by enlarging said spatter include angle theta 1, the thickness tz1 to the truck cross direction (the direction of illustration X) of other insulating layers 72 formed in side-face 31a of a crevice 31 can be formed more thickly than the thickness tz2 of other insulating layers 72 formed in base 31of top-face [of an insulating layer 71], and crevice 31 b. Thus, if thickness of other insulating layers 72 is not adjusted, even if other insulating layers 72 of side-face 31a of a crevice 31 will be removed altogether or other insulating layers 72 will remain by the ion milling in degree process, the thickness can become very thin and cannot be operated as an insulating layer for reducing a splitting loss appropriately.
[0329] Next, as shown in drawing 26 , it is an include angle (ion milling is given from the include angle of 0 to 20 degrees to the perpendicular direction on the front face of class of multilayers.) near the film surface, perpendicular direction (the direction of illustration X, and perpendicular direction), or perpendicular direction of each class of multilayers. Ion milling is given until it removes appropriately other insulating layers 72 formed in base 31b of a crevice 31 at this time. Other insulating layers 72 formed in top-face 71a of an insulating layer 71 of this ion milling are removed. On the other hand, although other insulating layers 72 formed in side-face 31a of a crevice 31

can be deleted a little It has the thickness tz1 thicker than other insulating layers 72 formed in base 31b of a crevice 31. Moreover, the direction H of milling of ion milling Since it will become whenever [shallow incident angle] if it sees from other insulating layers 72 formed in side-face 31a of a crevice 31, other insulating layers 72 formed in side-face 31a of a crevice 31 Compared with other insulating layers 72 formed in base 31b of a crevice 31, it is hard to be deleted, and, therefore, other insulating layers 72 of moderate thickness are left behind to side-face 31a of a crevice 31.
[0330] As for the thickness tz3 in the truck cross direction of other insulating layers 72 left behind to side-face 31a of a crevice 31, it is desirable that it is 5nm to 10nm.
[0331] As shown in drawing 26 , the 2nd antiferromagnetism layer 20 top face is covered with an insulating layer 71, and it will be covered with other insulating layers 72 by side-face 31a of a crevice 31. And as shown in drawing 27 , it applies to base 31b of a crevice 31 from insulating layers 71 and 72, and plating formation of the up electrode layer 73 which consists of magnetic materials, such as NiFe, and serves as an up shielding layer is carried out.
[0332] The magnetic sensing element shown in drawing 28 as mentioned above is formed. The magnetic sensing element shown in drawing 28 can cover the 2nd antiferromagnetism layer 20 top by the insulating layer 71, and can cover appropriately the side-face 31a top of a crevice 31 by other insulating layers 72 and 72, and the current which flows from a shielding layer does not carry out splitting to 2nd antiferromagnetism layer 20 grade, but said current flows appropriately the inside of other insulating layers 72 on base 31b of said crevice 31, and the width of recording track Tw determined spacing between 72. Therefore, if it is the magnetic sensing element of the structure shown in drawing 28 , it can control that a current path spreads from the width of recording track Tw decided at intervals of the truck cross direction of other insulating layers 72 and 72, and a playback output will be large and it will become possible to manufacture the magnetic sensing element of a CPP mold with the narrow effective width of recording track.
[0333] Furthermore, it can control appropriately that a current carries out splitting of the up electrode layer 73 to the both-sides section of multilayers since the current path over the multilayers from the free magnetic layer 17 to the substrate layer 13 is narrowed down by the crevice 31, and it becomes possible to manufacture a magnetic sensing element with a large playback output more effectively.
[0334] Moreover, the magnetic sensing element which has the crevice 32 as shown in drawing 29 can also be obtained after the process shown in drawing 23 by digging the 2nd antiferromagnetism layer 20 deep to the middle of the 2nd antiferromagnetism layer 20. As for a crevice 32, base 32b is located in the 2nd antiferromagnetism layer 20.
[0335] In the magnetic sensing element shown in drawing 29 , base 32b of a crevice 32 is located in the 2nd antiferromagnetism layer 20, the free magnetic layer 17 and the ferromagnetic layer 19 adjoin through a non-magnetic layer 18, and it will be in the ferrimagnetism condition that the magnetization direction of the free magnetic layer 17 and the magnetization direction of the ferromagnetic layer 19 serve as anti-parallel.
[0336] At this time, the multilayers F which consist of the free magnetic layer 17, a non-magnetic layer 18, and a ferromagnetic layer 19 function as one free magnetic layer and a so-called synthetic ferry free magnetic layer.
[0337] At this time, thickness t2 of the field located in the lower part of base 32b of a crevice 32 of the 2nd antiferromagnetism layer 20 is made into 50A or less more greatly than 0A. If thickness t2 of the field located in the lower part of base 32b of a crevice 32 of the 2nd antiferromagnetism layer 20 is made into 50A or less like the gestalt of this operation more greatly than 0A, a switched connection field will not occur in the field of the 2nd antiferromagnetism layer 20 located in the lower part of base 32b of a crevice 32. And in the truck cross direction both-sides sections S and S in which a crevice 32 is not formed, a switched connection field occurs between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19.
[0338] That is, the magnetization direction of the ferromagnetic layer 19 is fixed by the switched connection field between the 2nd antiferromagnetism layer only in the truck cross direction both-sides sections S and S other than the field which laps with base 32b of a crevice 32. Therefore, the magnetization direction of the free magnetic layer 17 by which the laminating is carried out to the lower layer of the ferromagnetic layer 19 through the non-magnetic layer 18 is also fixed only in the truck cross direction both-sides sections S and S by the RKKY interaction with the ferromagnetic layer 19.
[0339] the condition that, as for the field E of the free magnetic layer 17 which laps with base 32b of a crevice 32, an external magnetic field is not impressed -- it is, it learns from the both-sides sections S and S to which the magnetization direction was fixed, and is arranged in the direction of illustration X, and if an external magnetic field is impressed, the magnetization direction will change.
[0340] Moreover, the magnetic sensing element which has the crevice 32 as shown in drawing 30 can also be obtained by digging deep to the middle of the ferromagnetic layer 19 after the process shown in drawing 23 . As for a crevice 32, side-face 32a penetrates the 2nd antiferromagnetism layer 20, and base 32b is located in the ferromagnetic layer 19.

[0341] The multilayers F which consist of the free magnetic layer 17, a non-magnetic layer 18, and a ferromagnetic layer 19 also by the magnetic sensing element shown in drawing 30 function as one free magnetic layer and a so-called synthetic ferry free magnetic layer F. In this invention, the 2nd antiferromagnetism layer 20 does not exist in the upper layer of the sensibility field E where the magnetization direction changes with external magnetization of a free magnetic layer at all. Therefore, fluctuation of the external magnetic field dependency of the magnetization direction of the sensibility field E of the synthetic ferry free magnetic layer F can be made sharp, and the field detection sensitivity of a magnetic sensing element can be improved.

[0342] Moreover, in the process shown in drawing 21 , when forming multilayers A1, the ingredient 50 with specific resistance lower than a non-magnetic layer 18, for example, the conductive ingredient layer which consists of Cu, is formed between a non-magnetic layer 18 and the free magnetic layer 17, and the magnetic sensing element finally shown in drawing 31 may be made to be obtained.

[0343] If the conductive ingredient layer 50 which specific resistance becomes from a conductive ingredient lower than a non-magnetic layer 18 is formed, since it can do now the bigger spin filter effectiveness than the case of only a non-magnetic layer 18 so and the field detection sensitivity of a magnetic sensing element can be raised further, it is desirable. In addition, if the conductive ingredient layer 50 is formed using Cu, the value of the free magnetic layer 17 formed of NiFe or CoFeNi and a crystal-lattice constant becomes near, and can do the big spin filter effectiveness so.

[0344] When forming the conductive ingredient layer 50, a non-magnetic layer 18 can be formed by Ru as that whose thickness t3 is 0.4-1.1nm, and the conductive ingredient layer 50 can be further formed by Cu as that whose thickness t4 is 0.3-0.5nm.

[0345] Moreover, in the process shown in drawing 21 , when forming multilayers A1 Carried out the laminating of 1st free magnetic layer 40a (ferromagnetic ingredient layer) and 2nd free magnetic layer 40c (ferromagnetic ingredient layer) from which the magnitude of the magnetic moment per unit area differs the free magnetic layer 40 through nonmagnetic interlayer 40b. It forms as the so-called synthetic ferry free type of a free magnetic layer, and you may make it obtain the magnetic sensing element finally shown in drawing 32 . the [in addition,] -- the [1 free magnetic layer 40a (ferromagnetic ingredient layer) and] -- as for the ingredient and thickness of 2 free magnetic layer 40c (ferromagnetic ingredient layer) and nonmagnetic interlayer 40b, it is desirable to make it the same as the free magnetic layer 40 of the magnetic sensing element shown in drawing 17 .

[0346] The free magnetic layer 40 of the magnetic sensing element shown in drawing 32 is in the artificial ferrimagnetism condition that the magnetization direction of a ferromagnetic ingredient layer where the laminating of two or more ferromagnetic ingredient layers from which the magnitude of the magnetic moment per unit area differs is carried out through a non-magnetic layer, and they adjoin through a non-magnetic layer serves as anti-parallel.

[0347] The lower electrode layer 70 the magnetic sensing element shown in drawing 29 thru/or drawing 32 both [layer / bottom / of the 1st antiferromagnetism layer 14] also used the lower shielding layer is formed. An insulating layer 71 is formed on the 2nd antiferromagnetism layer 20. Moreover, side-face 31a of crevices 31, 32, and 33, Other insulating layers 72 are formed in 32a and 33a, and the up electrode layer 73 which applied from on an insulating layer 71 and other insulating layers 72 further on the bases 31b and 32b of crevices 31, 32, and 33 and 33b, and made the up shielding layer serve a double purpose is formed.

[0348] Like the gestalt of this operation, if a non-magnetic layer 18 is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os, in the 1st annealing in a magnetic field, the front face of a non-magnetic layer 18 will hardly oxidize. Therefore, before carrying out spatter membrane formation of the ferromagnetic layer 19 on a non-magnetic layer 18, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the RKKY interaction which minded the non-magnetic layer 18 between the free magnetic layer 17 and the ferromagnetic layer 19 can be used. For example, when both the free magnetic layer 17 and the ferromagnetic layer 19 are formed by NiFe and a non-magnetic layer 18 is formed by Ru, even if it does not process the front face of a non-magnetic layer 18 by milling etc., the one direction anisotropy field of 42 (kA/m) can be generated.

[0349] That is, since it can end even if it does not make the interface of a non-magnetic layer 18 and the ferromagnetic layers 19 and 19 into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the anti-parallel joint field between the free magnetic layer 17 and the ferromagnetic layer 19 and the magnetization direction of the free magnetic layer 17 in the fixed direction can be prevented.

[0350] However, even when the front face of a non-magnetic layer 18 is processed by milling, the ferromagnetic layer 19 and the free magnetic layer 17 can carry enough the switched connection field between the 2nd antiferromagnetism layer 20 and the ferromagnetic layer 19 in the free magnetic layer 17 through a non-magnetic layer 18, and since it is magnetically combined by the RKKY interaction through a non-magnetic layer 18, in order to arrange the magnetization direction of a free magnetic layer in the fixed direction, they can obtain sufficient one direction anisotropy field.

[0351] Furthermore, if a non-magnetic layer 18 is formed by Ru and the free magnetic layer 17 is formed by CoFe,

it is also possible to set magnetostriction of the free magnetic layer 17 to 0.
[0352] In addition, the magnetic sensing element of the gestalt of this operation can form the 1st antiferromagnetism layer 14 and the 2nd antiferromagnetism layer 20 using the antiferromagnetism ingredient of the same presentation.
[0353] Although the magnetic sensing element shown in drawing 33 and drawing 34 is a magnetic sensing element of a CPP mold as well as the magnetic sensing element of drawing 28 , the configuration of the lower electrode layer 80 which serves as a lower shielding layer differs from it of drawing 28 .
[0354] It has the film configuration of the same multilayers A as drawing 28 , moreover, an insulating layer 71 is formed on the 2nd antiferromagnetism layer 20, other insulating layers 72 are formed in side-face 31a of a crevice 31, the up electrode layer 73 which applied on base 31b of a crevice 31 from on the insulating layer 71 further, and made the up shielding layer serve a double purpose is formed, and the magnetic sensing element shown in drawing 33 is in agreement with drawing 28 at this point.
[0355] Differing from drawing 28 in the center section of the truck cross direction (the direction of illustration X) of the lower electrode layer 80 which made the lower shielding layer which consists of magnetic materials, such as NiFe, serve a double purpose Lobe 80a projected in the direction (illustration Z direction) of multilayers A was prepared, the top face 80a1 of this lobe 80a is in contact with the inferior surface of tongue of Multilayers A, and it is the point that a current flows in Multilayers A from lobe 80a (to or lobe 80from Multilayers A a).
[0356] And in the magnetic sensing element shown in drawing 33 , the insulating layer 81 is formed between both-sides edge 80b in the truck cross direction (the direction of illustration X) of the lower electrode layer 80, and Multilayers A. An insulating layer 81 is formed by insulating materials, such as aluminum 2O3, SiO2, AlN and Ti 2O3, Ti3O5, and aluminum-Si-O.
[0357] In the magnetic sensing element shown in drawing 33 , the current path over Multilayers A is narrowed down by formation of lobe 80a, the lower electrode layer 80 is that the insulating layer 81 was further formed between both-sides edge 80b of the lower electrode layer 80, and Multilayers A, and can control appropriately that a current carries out splitting into Multilayers A from both-sides edge 80b, and it becomes possible to manufacture a magnetic sensing element with a large playback output more effectively.
[0358] In addition, although the width method of the truck cross direction (the direction of illustration X) of the top face 80a1 of lobe 80a of the lower electrode layer 80 is in agreement with the width method in the truck cross direction (the direction of illustration X) of Field E in the magnetic sensing element shown in drawing 33 , the width method of a top face 80a1 may be larger than the width method of Field E. It is that the width method of a top face 80a1 is in agreement with the width of recording track Tw more preferably. It is possible to be able to pass a current and to manufacture a magnetic sensing element with a large playback output only in the field of the width of recording track Tw, to Multilayers A, more effectively, by this.
[0359] With the operation gestalt shown in drawing 33 , moreover, the both-sides side 80a2 in the truck cross direction (the direction of illustration X) of lobe 80a formed in the lower electrode layer 80 Although formed in respect of the inclined plane where the width method in the truck cross direction of lobe 80a follows for separating from Multilayers A (an illustration Z direction and hard flow), and spreads gradually, or the curve, the both-sides side 80a2 may be a vertical plane to the truck cross direction (the direction of illustration X).
[0360] The operation gestalt shown in drawing 34 has the lower electrode layer 80 of the same configuration as the operation gestalt shown in drawing 33 . That is, lobe 80a projected in the direction (illustration Z direction) of multilayers A was prepared in the center section of the truck cross direction (the direction of illustration X) of the lower electrode layer 80 shown in drawing 34 , the top face 80a1 of this lobe 80a is in contact with the inferior surface of tongue of Multilayers A, and a current flows in Multilayers A from lobe 80a (to or lobe 80from Multilayers A a). And the insulating layer is prepared between both-sides edge 80b in the truck cross direction (the direction of illustration X) of the lower electrode layer 80, and Multilayers A.
[0361] With the operation gestalt shown in drawing 34 , unlike drawing 33 , an insulating layer 71 is not formed on the 2nd antiferromagnetism layer 20, and other insulating layers 72 are not formed in side-face 31a of a crevice 31. And it consists of magnetic materials, such as NiFe, and it is directly joined from on the 2nd antiferromagnetism layer 20, up electrode applying [which makes an up shielding layer serve a double purpose / 73] it on side-face 31a of a crevice 31, and base 31b.
[0362] Although it is thought with the operation gestalt shown in drawing 34 that a current path is inferior to the width of recording track Tw in breadth or the playback output which becomes empty since between the up electrode layer 73 and the 2nd antiferromagnetism layer 20 and between side-face 31a of the up electrode layer 73 and a crevice 31 are not insulated compared with the operation gestalt shown in drawing 33 By the inferior-surface-of-tongue side of Multilayers A, by lobe 80a formed in the lower electrode layer 80, a current path can be narrowed down, the breadth of a current path can be stopped, and the fall of a playback output can be controlled.
[0363] Moreover, it is desirable that the top face 80a1 of lobe 80a formed in the lower electrode layer 80 and top-face 81a of the insulating layer 81 formed in the both sides are formed at the same flat surface in the magnetic

sensing element shown in drawing 33 and drawing 34 . The film surface of each class of the multilayers A formed on an insulating layer 81 from on lobe 80a of this, applying can be formed more crosswise [truck] at parallel, and it becomes possible to manufacture the magnetic sensing element excellent in reproducing characteristics.
[0364] The manufacture approach of the lower electrode layer 80 of the magnetic sensing element shown in drawing 33 and drawing 34 and an insulating layer 81 is explained.
[0365] First, as shown in drawing 35 , after plating or spatter forming the lower electrode layer 80 and carrying out data smoothing of the front face by polishing etc. using magnetic materials, such as NiFe, the resist layer 92 is formed on the center section of the truck cross direction (the direction of illustration X) of the lower electrode layer 80.
[0366] Next, as shown in drawing 36 , both-sides edge 80b of the lower electrode layer 80 which is not covered with this resist layer 92 is deleted to the middle by ion milling. Lobe 80a can be formed in the center section of the truck cross direction of the lower electrode layer 80 by this.
[0367] Furthermore, as shown in drawing 37 , when spatter membrane formation of the insulating layer 81 is carried out on both-sides end-face 80b of the lower electrode layer 80 which is not covered with the resist layer 92 and top-face 81a of an insulating layer 81 becomes the top face 80a1 of lobe 80a of the lower electrode layer 80 with the same flat surface mostly, said spatter membrane formation is ended. And the resist layer 92 is removed.
[0368] In addition, after removing the resist layer 92, top-face 81of top-face [of lobe 80a of the lower electrode layer 80] 80a1 and insulating layer 81 a is ground using CMP etc., and top-face 81a of the top face 80a1 of lobe 80a and an insulating layer 81 may be made to become the same flat surface with high precision. In this case, data smoothing, such as the first polishing, is omissible.
[0369] After removing the resist layer 92, the laminating of the multilayers A is carried out on the lower electrode layer 80 and an insulating layer 81.
[0370] Although multilayers touch up and down and the up electrode layer 73 which serves both as the lower electrode layers 70 or 80 and up shielding layer which serve as a lower shielding layer is formed in the magnetic sensing element of the CPP mold shown in drawing 28 thru/or drawing 34 , it becomes possible to lose the need of forming an electrode layer and a shielding layer separately, and to easy-ize manufacture of the magnetic sensing element of a CPP mold by such configuration.
[0371] And if an electrode function and a shielding function are made to make it serve a double purpose, gap length G1 determined spacing between shielding layers can be shortened very much, and it will become possible to manufacture appropriately the magnetic sensing element which can respond by future high recording density-ization.
[0372] However, if required, after carrying out the laminating of the non-magnetic layer 74 which was missing from the bases 31b, 32b, and 33b of crevices 31, 32, and 33 from insulating layers 71 and 72, and was shown by the dotted line, the up electrode layer 73 may be formed on a non-magnetic layer 74. As for a non-magnetic layer 74, it is desirable to be formed with nonmagnetic electrical conducting materials, such as Ta, Ru, Rh, Ir, Cr, Re, and Cu.
[0373] Although a non-magnetic layer 74 has a role of an up gap layer, since said current stops being able to flow in multilayers easily, the non-magnetic layer 74 of covering by the non-magnetic layer 74 which consists of an insulating material, since it is formed also in the bases 31b, 32b, and 33b of the crevices 31, 32, and 33 used as the entrance of a current path is not desirable. Therefore, it is desirable to form a non-magnetic layer 74 with a nonmagnetic electrical conducting material in this invention.
[0374] Moreover, you may be the configuration of preparing the electrode layer which consists of Au, W, Cr, Ta, etc. in the top face and/or inferior surface of tongue of multilayers, and preparing the shielding layer made from a magnetic material in the field of the electrode layer of multilayers and the opposite side through a gap layer in this invention.
[0375] Also in the magnetic sensing element of the CPP mold shown in drawing 28 thru/or drawing 34 , the same effectiveness as drawing 6 , drawing 7 , drawing 8 , drawing 12 , drawing 15 R> 5, drawing 16 , and the magnetic sensing element of the CIP mold of drawing 17 is expectable.
[0376] That is, in this invention, since crevices 31, 32, and 33 can be formed only by deleting perpendicularly the 2nd antiferromagnetism layer formed by uniform thickness to the truck cross direction (the direction of illustration X) using reactive ion etching (RIE) or ion milling, it becomes possible to form crevices 31, 32, and 33 by the exact width method. That is, the width of recording track Tw of a magnetic sensing element can be specified correctly.
[0377] Moreover, since an insensible field is not generated to the field of the width of recording track (optical width of recording track) Tw set up at the time of formation of a magnetic sensing element, and it corresponds to high recording density-ization, the fall of the playback output at the time of making small the optical width of recording track Tw of a magnetic sensing element can be suppressed.
[0378] Furthermore, since it is possible to be formed so that the side edge side of a magnetic sensing element may become perpendicular to the truck cross direction with the gestalt of this operation, it can stop with [of the truck cross direction die length of the free magnetic layer 17] a rose. It becomes possible to control generating of side

leading appropriately by the above.
[0379] In addition, by the magnetic sensing element shown in drawing 28 thru/or drawing 34 , the non-magnetic material layer 16 may be formed with nonmagnetic electrical conducting materials, such as Cu, or the non-magnetic material layer 16 may be formed by insulating materials, such as aluminum 2O3 and SiO2. The former magnetic sensing element is structure (CPP-GMR) called a spin bulb GMR mold magneto-resistive effect component, and the latter magnetic sensing element is structure called a spin bulb tunnel mold magneto-resistive effect mold component (CPP-TMR).
[0380] A tunnel mold magneto-resistive effect mold component produces resistance change using the tunnel effect, when magnetization with the fixed magnetic layer 15 and the free magnetic layer 17 is anti-parallel, the tunnel current which minded the non-magnetic material layer 16 most stops being able to flow easily, resistance becomes max, on the other hand, when magnetization with the fixed magnetic layer 15 and the free magnetic layer 17 is parallel, tunnel current becomes the easiest to flow, and resistance becomes min.
[0381] When using this principle and changing magnetization of the free magnetic layer 17 in response to the effect of an external magnetic field, the changing electric resistance is regarded as electrical-potential-difference change (in the case of constant current actuation), or current change (in the case of constant-voltage actuation), and the leak field from a record medium is detected.
[0382] In addition, especially in case especially the magnetic sensing element of a CPP-GMR mold sets 0.1 micrometers or less of optical width of recording track Tw to 0.06 micrometers or less and corresponds to two or more 200 Gbit/in recording density, it is effective.
[0383] It writes in on the CIP mold MAG sensing element of the gestalt of the operation explained in full detail above, and a CPP mold MAG sensing element, and the laminating of the inductive component of business may be carried out.
[0384] Moreover, the magnetic sensing element of this invention is used for a magnetometric sensor, a hard disk, etc.
[0385]
[Effect of the Invention] As mentioned above, since this invention explained to the detail carries out the laminating of said ferromagnetic layer and said 2nd antiferromagnetism layer in the process of the above (c) on the front face of said non-magnetic layer formed as a flat side It becomes easy to enlarge the RKKY interaction between said ferromagnetic layers and said free magnetic layers in the synthetic ferry structure where can also form said ferromagnetic layer and said 2nd antiferromagnetism layer as a layer by which flattening was carried out, and they consist of said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer.
[0386] Moreover, if the laminating of said ferromagnetic layer and said 2nd antiferromagnetism layer is carried out on said non-magnetic layer which is a flat side, control of the laminating process of said ferromagnetic layer and said 2nd antiferromagnetism layer will become easy. In the synthetic ferry structure which consists of said ferromagnetic layer, said non-magnetic layer, and said free magnetic layer especially, said ferromagnetic layer can be formed thinly, and it becomes easy to enlarge the spin FUROPPU field between said ferromagnetic layers and said free magnetic layers.
[0387] Moreover, in this invention, since the magnetic material layer which is said free magnetic layer is extended and formed even in the lower layer of said 2nd antiferromagnetism layer and said ferromagnetic layer, magnetization of said free magnetic layer can make it small to be influenced [which is generated by the surface magnetic charge of the both-sides edge of said free magnetic layer] of an anti-field.
[0388] Moreover, since said multilayers are annealed among a magnetic field and the magnetization direction of said fixed magnetic layer is fixed in the predetermined direction in the condition of not carrying out the laminating of the 2nd antiferromagnetism layer, on said multilayers in this invention, where the laminating of the 2nd antiferromagnetism layer is carried out on said multilayers, the exchange anisotropy field has not occurred in said 2nd antiferromagnetism layer.
[0389] That is, the exchange anisotropy field of said 2nd antiferromagnetism layer is produced for the first time in the process of the above (e), and it becomes easy to move the magnetization direction of said free magnetic layer in the predetermined direction. Therefore, it becomes easy to fix the magnetization direction of said free magnetic layer in the magnetization direction of said fixed magnetic layer and the direction which intersects perpendicularly.
[0390] Moreover, in the magnetic sensing element manufactured by the manufacture approach of this invention, the width of recording track is determined with the distance-across-vee dimension of said crevice. That is, the magnetization direction of a magnetic layer where the magnetization direction changes with external magnetic fields, such as said free magnetic layer, can be changed only in the part which laps with the base of said crevice. And since said crevice can form said 2nd antiferromagnetism layer formed by uniform thickness only by deleting to the perpendicular direction to the truck cross direction using reactive ion etching (RIE) or ion milling, it becomes possible to form said crevice by the exact width method. That is, the width of recording track of a magnetic sensing element can be specified correctly.

[0391] In addition, if said non-magnetic layer is formed with one sort or two sorts or more of alloys among Ru, Rh, Ir, Re, and Os in this invention, the front face of said non-magnetic layer will hardly oxidize. Therefore, before carrying out spatter membrane formation of said ferromagnetic layer on said non-magnetic layer, even if it does not process the front face of said non-magnetic layer by milling etc., the RKKY interaction which minded said non-magnetic layer between said free magnetic layers and said ferromagnetic layers can be used.

[0392] That is, since according to the manufacture approach of the magnetic sensing element of this invention it can end even if it does not make the interface of said non-magnetic layer and said ferromagnetic layer into the field from which it was deleted by milling, the fall of the one direction anisotropy field for arranging the magnetization direction in the both-sides section of said free magnetic layer in the fixed direction can be prevented.

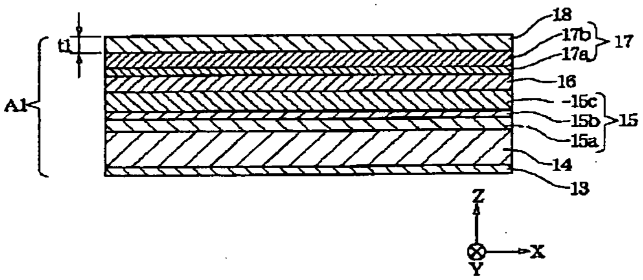
[0393] Moreover, the magnetic sensing element in this invention is applicable to both also by the magnetic sensing element of a CIP mold, or the magnetic sensing element of a CPP mold.

[Translation done.]

DRAWINGS

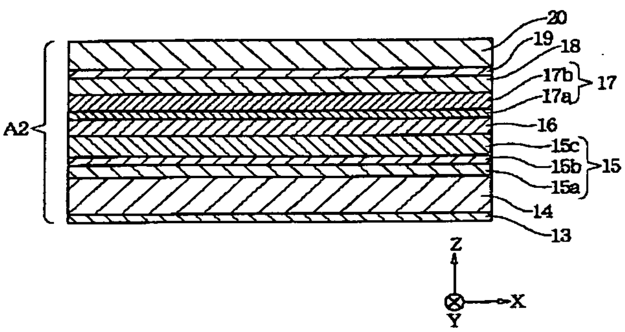
[Drawing 1]

図1



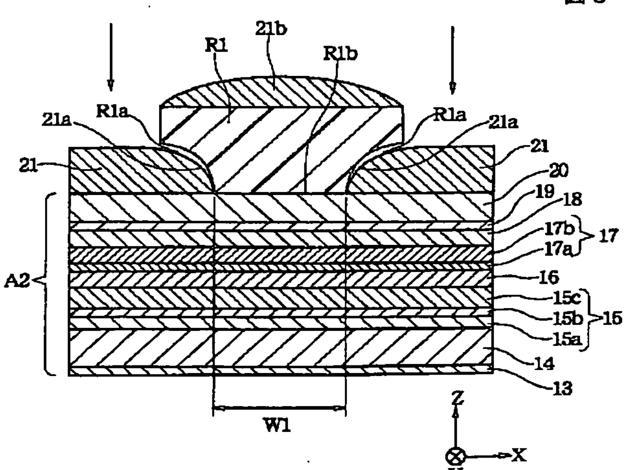
[Drawing 2]

図2



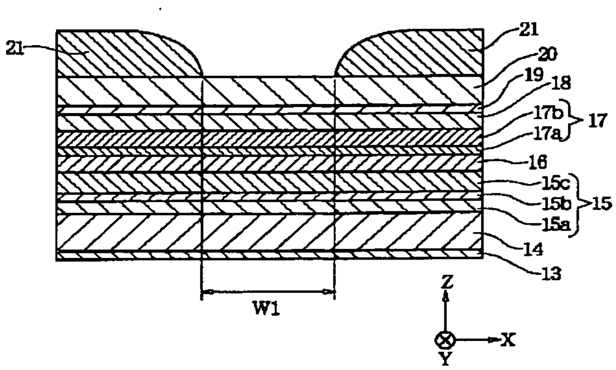
[Drawing 3]

図3



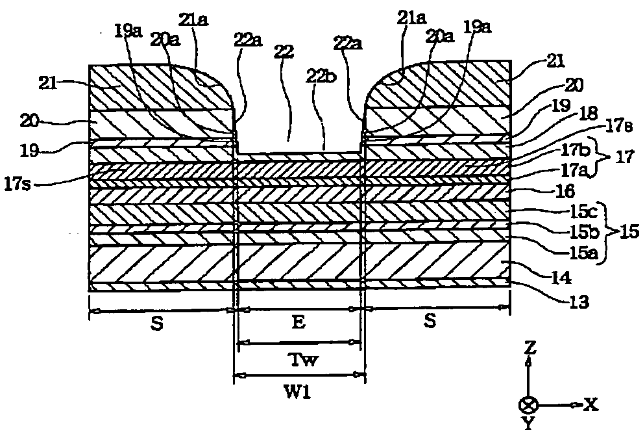
[Drawing 4]

図4



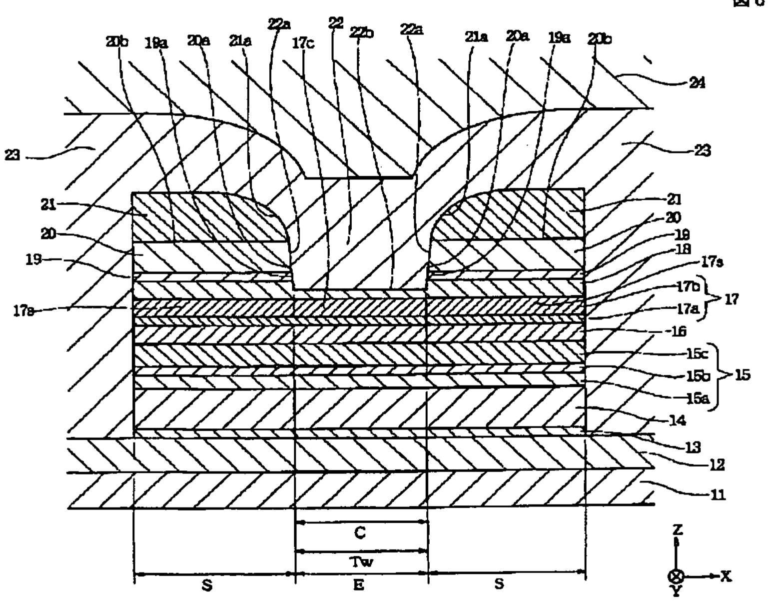
[Drawing 5]

図5



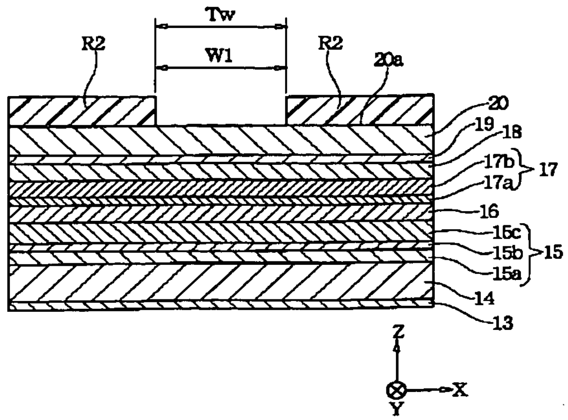
[Drawing 6]

図6



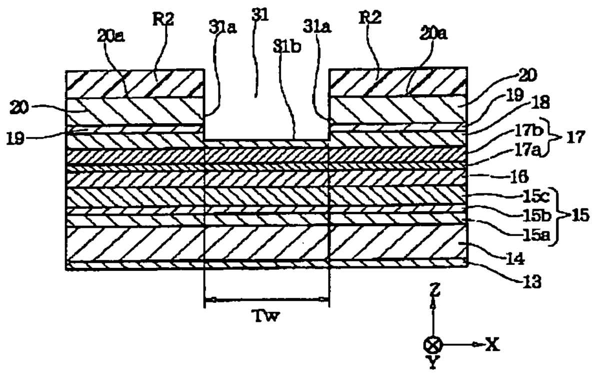
[Drawing 9]

図 9



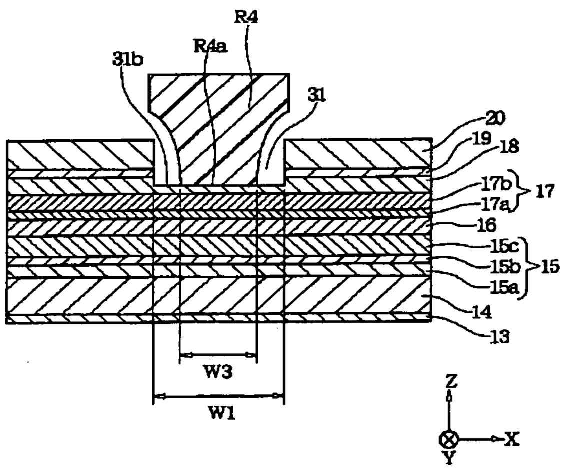
[Drawing 10]

図 10



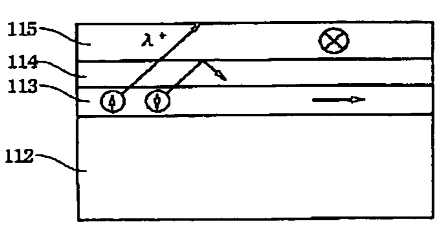
[Drawing 13]

図 13



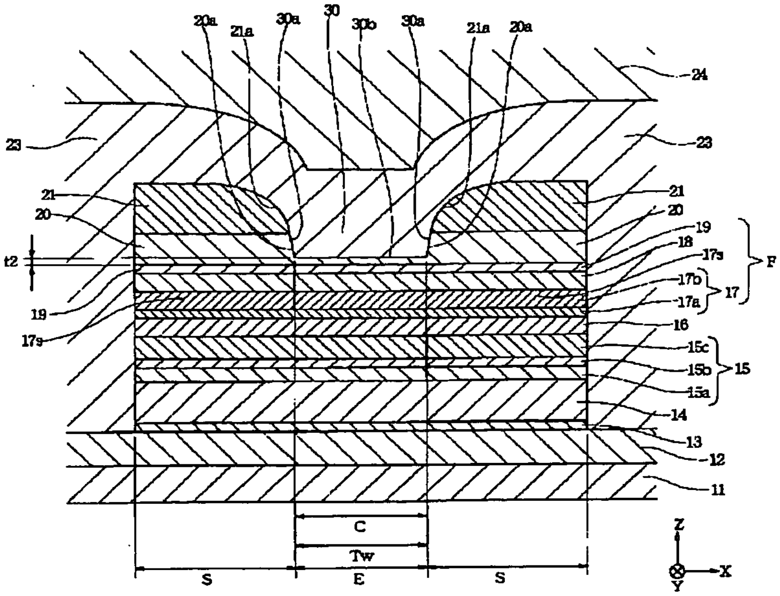
[Drawing 19]

図 19



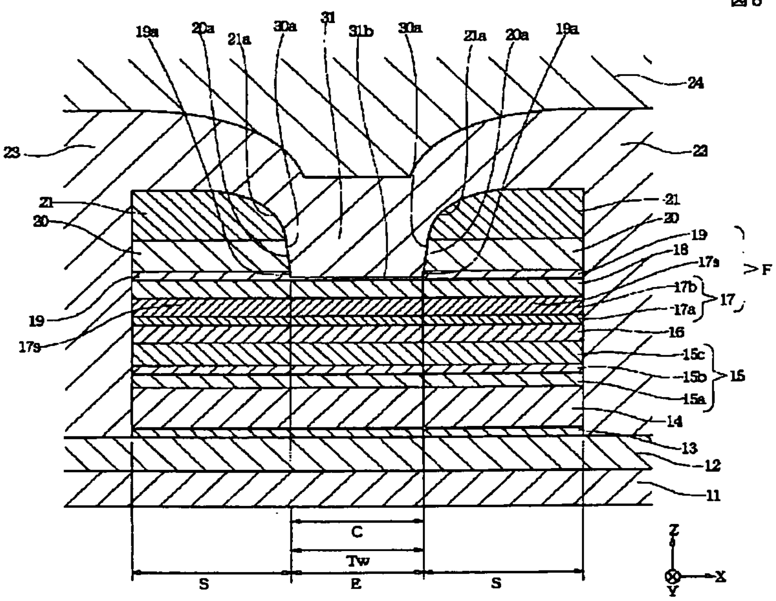
[Drawing 7]

図7



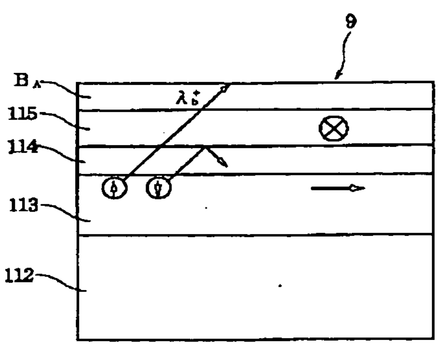
[Drawing 8]

図8



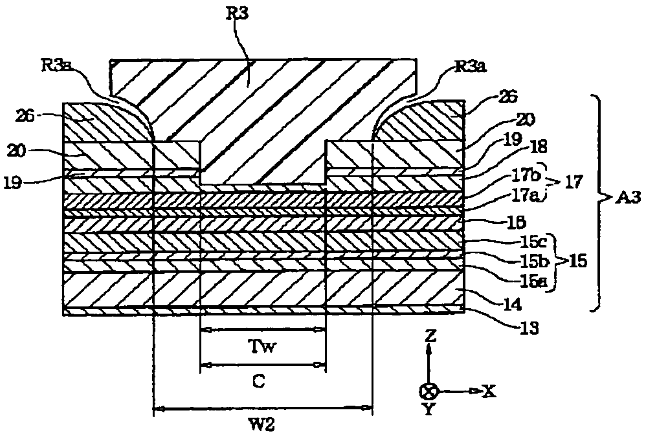
[Drawing 20]

図20



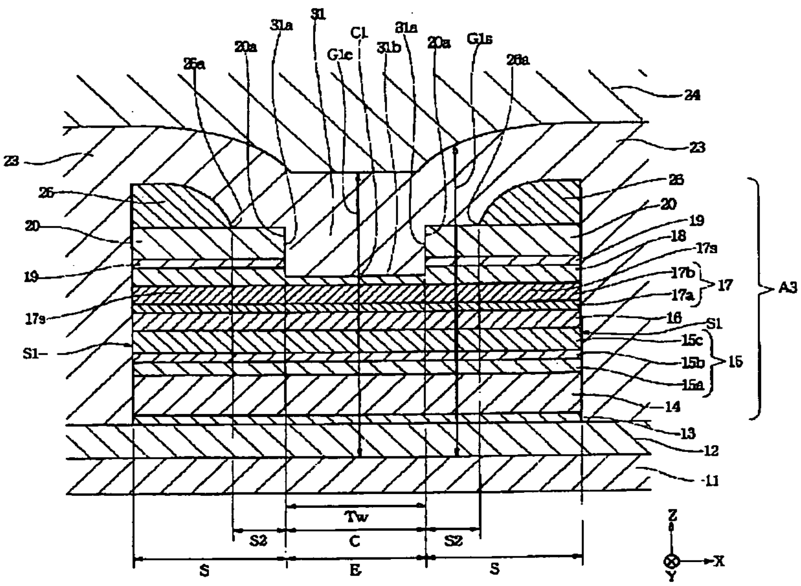
[Drawing 11]

図 11



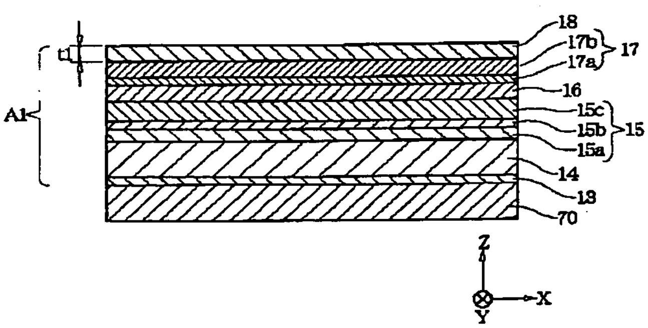
[Drawing 12]

図 12



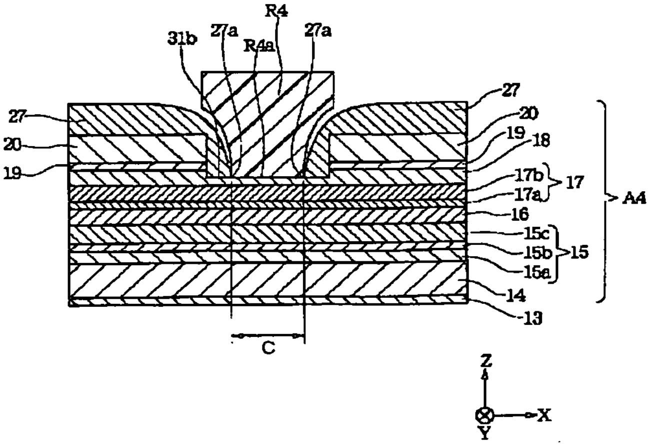
[Drawing 21]

図 21



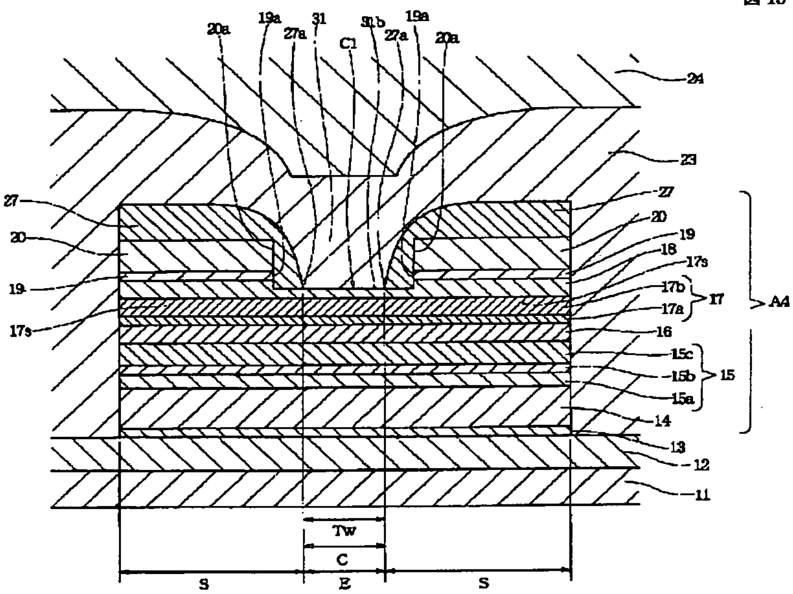
[Drawing 14]

図 14



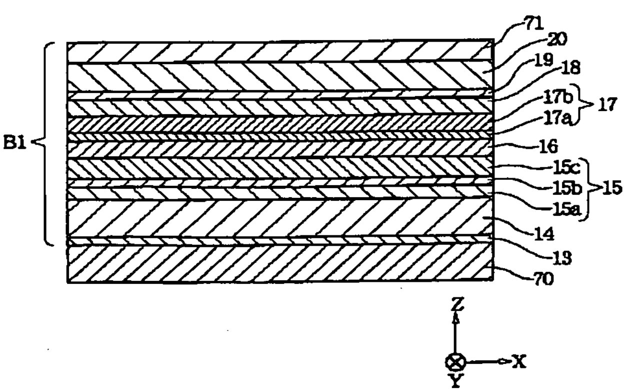
[Drawing 15]

図 15



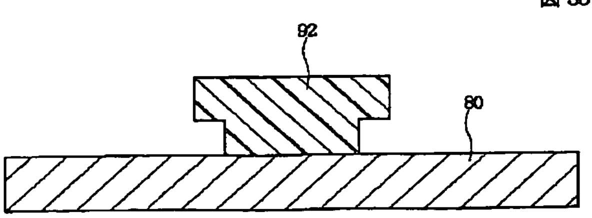
[Drawing 22]

図 22



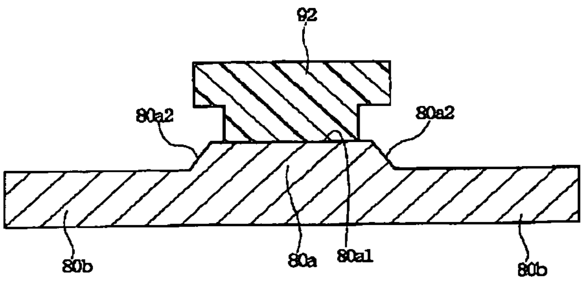
[Drawing 35]

図 35



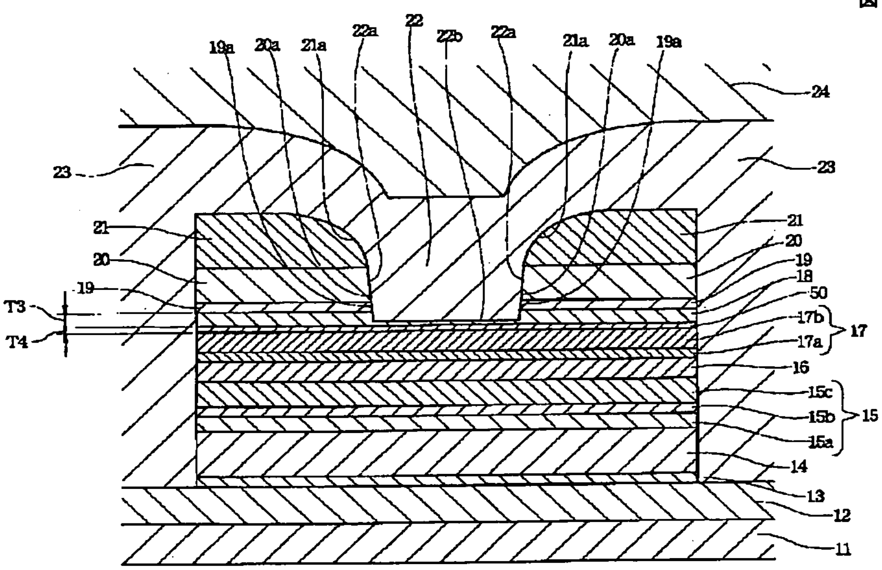
[Drawing 36]

図 36



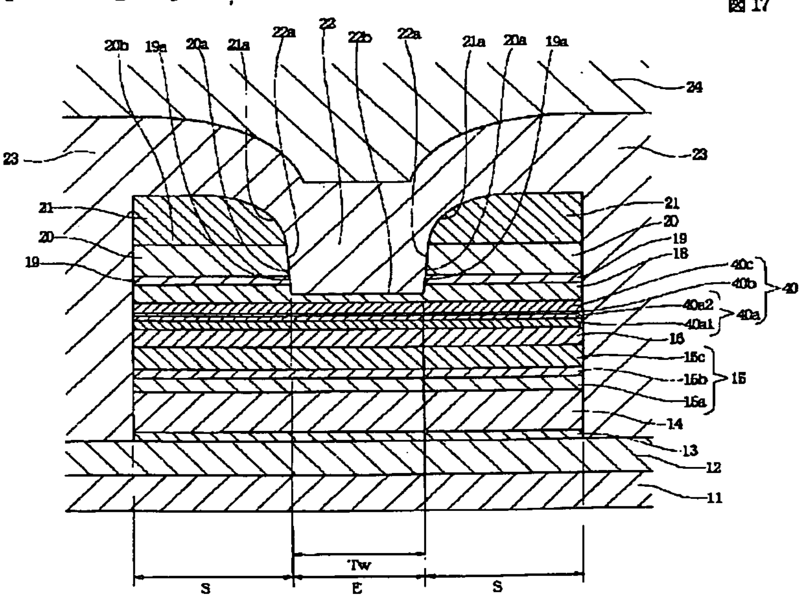
[Drawing 16]

図 16



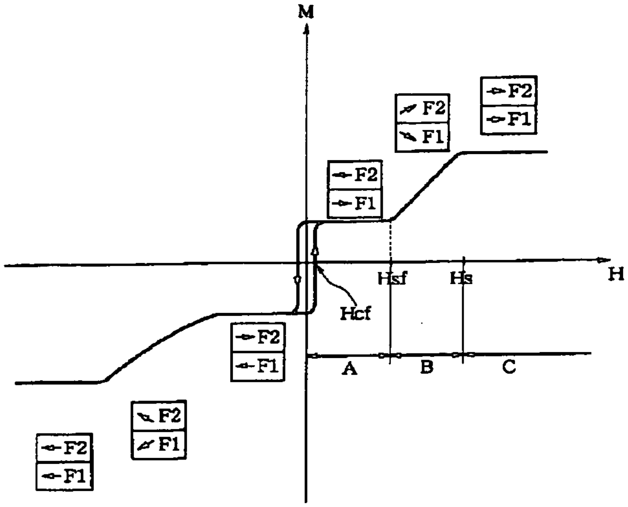
[Drawing 17]

図 17



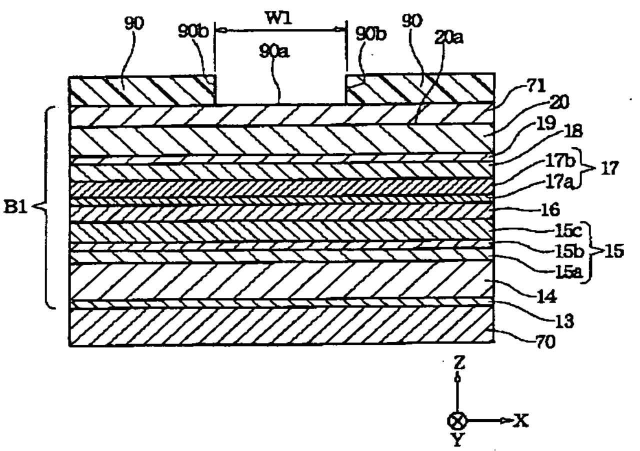
[Drawing 18]

図 18



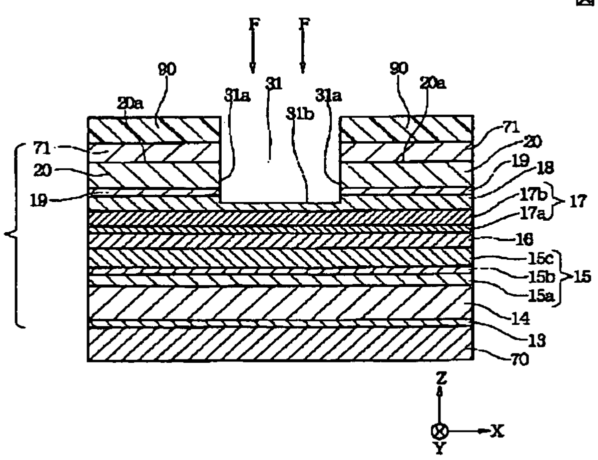
[Drawing 23]

図 23



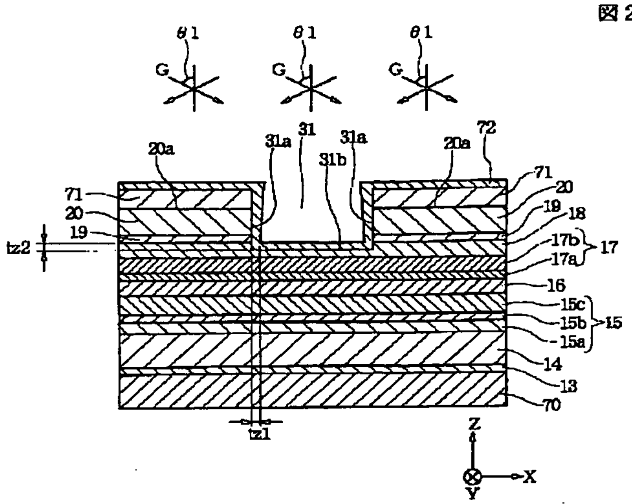
[Drawing 24]

図 24



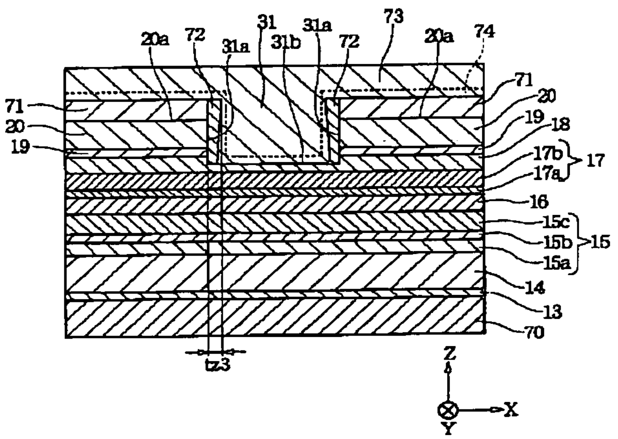
[Drawing 25]

図 25



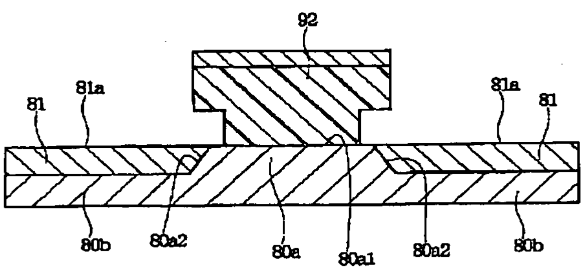
[Drawing 27]

図 27



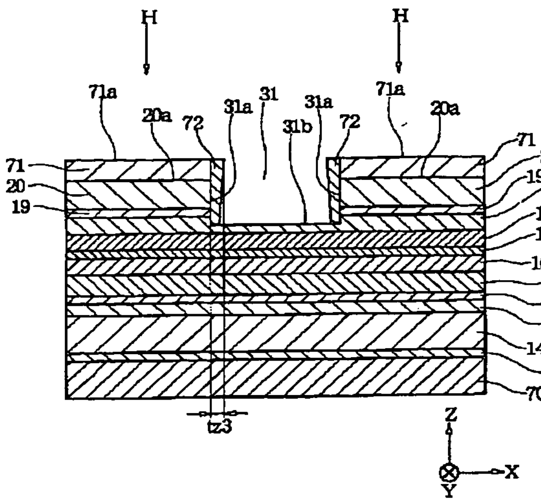
[Drawing 37]

図 37



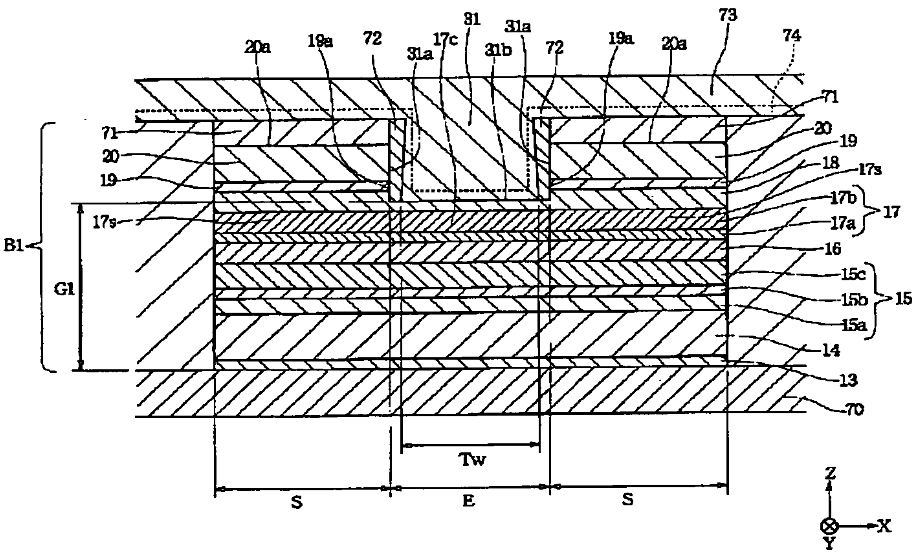
[Drawing 26]

図 26



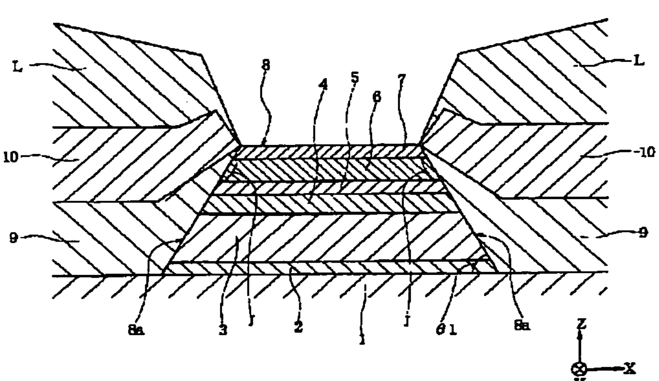
[Drawing 28]

図 28



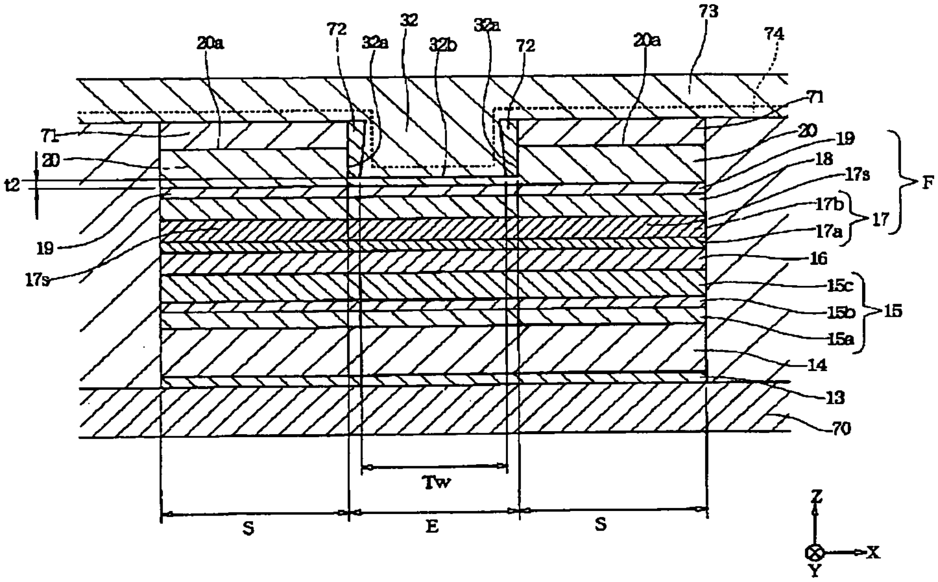
[Drawing 38]

図 38



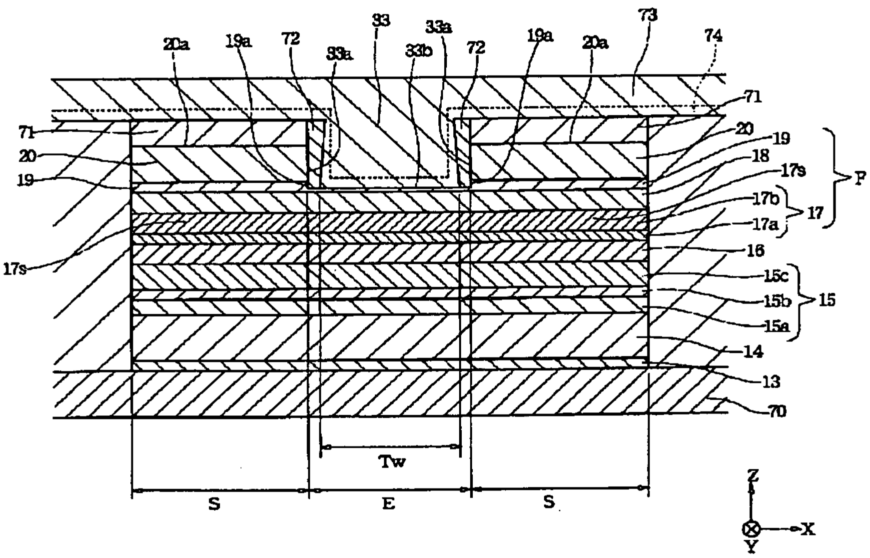
[Drawing 29]

図 29



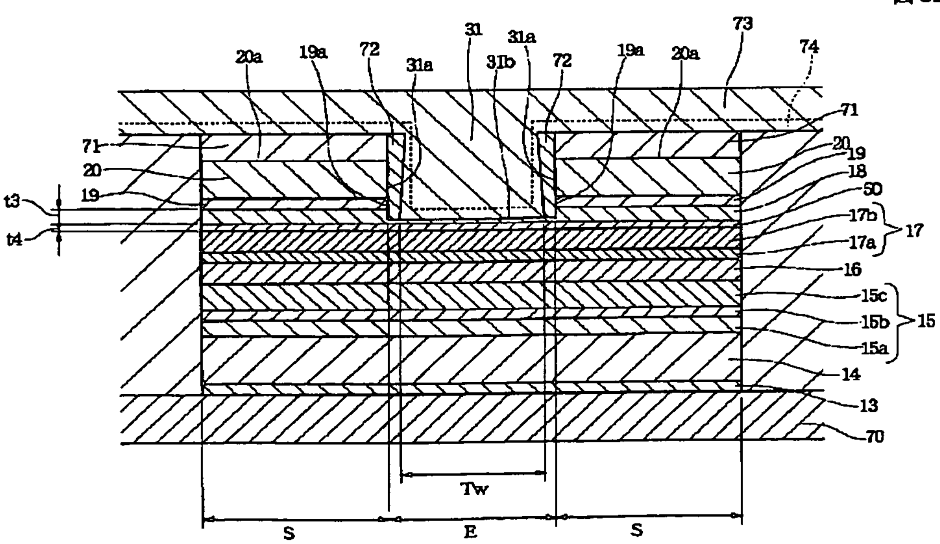
[Drawing 30]

図 30



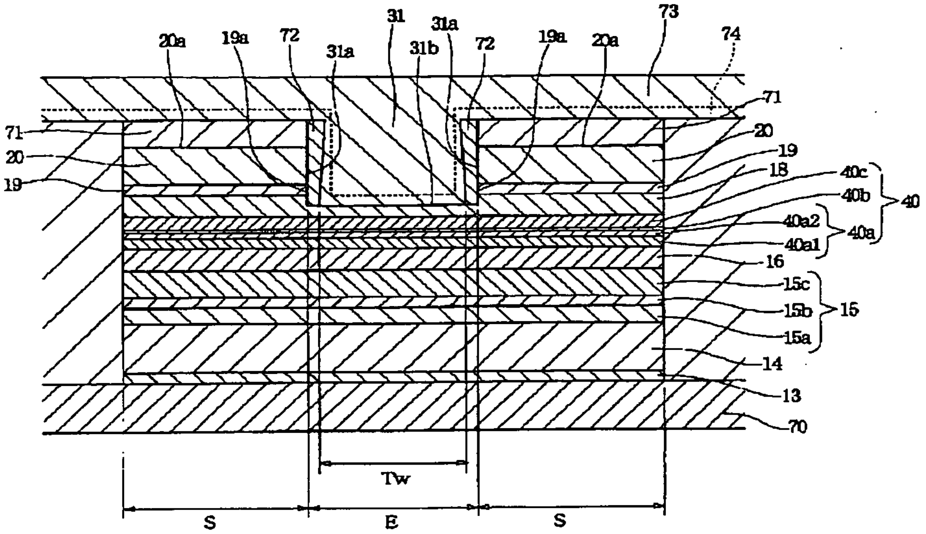
[Drawing 31]

図 31



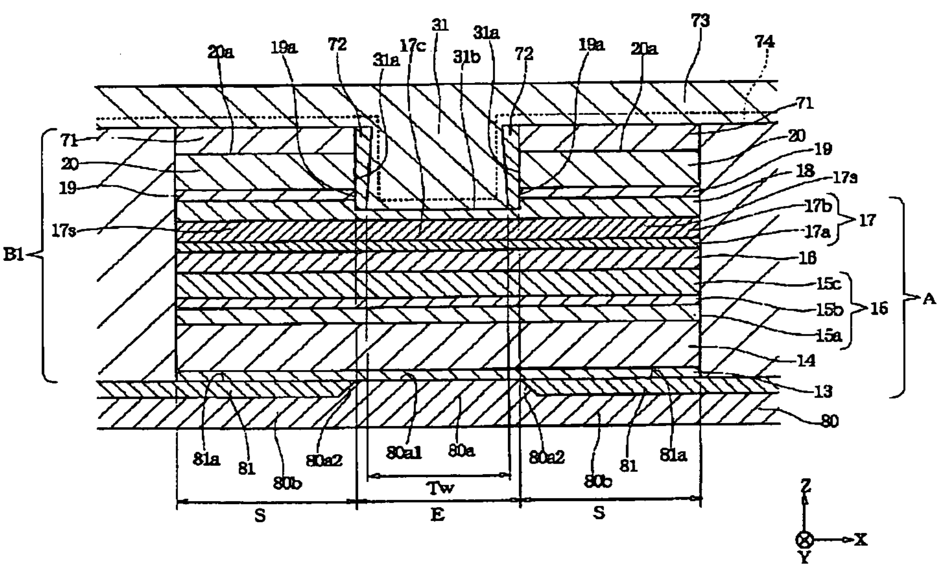
[Drawing 32]

図 32



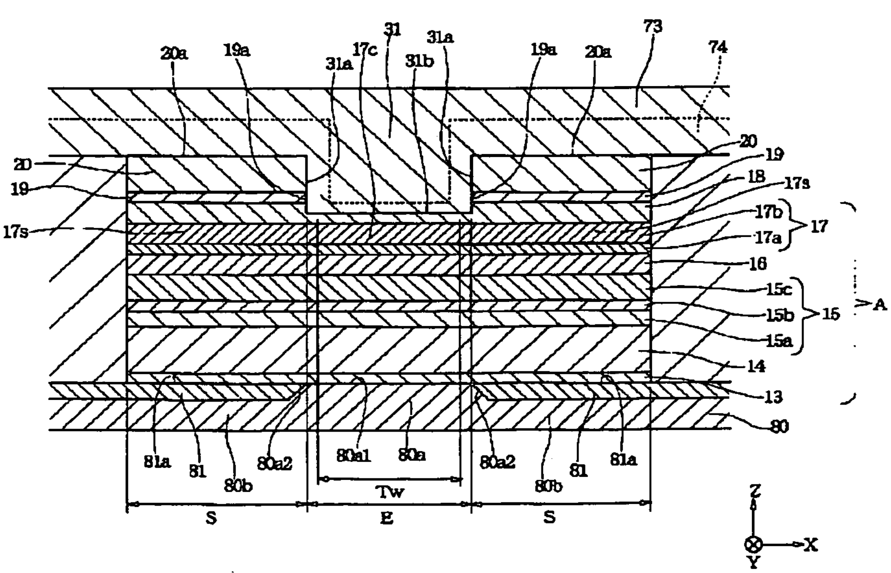
[Drawing 33]

図 33



[Drawing 34]

図 34



[Translation done.]